PROCEEDINGS

OF THE

NATIONAL ACADEMY OF SCIENCES
INDIA

1957

VOL. XXVI SECTION A PART VI

NOVEMBER 1957

PROCEEDINGS
OF
THE SYMPOSIUM
ON
CONSTITUTION OF STARS

NATIONAL ACADEMY OF SCIENCES, INDIA
ALLAHABAD

THE NATIONAL ACADEMY OF SCIENCES, INDIA

(Registered under Act XXI of 1860)

Founded 1930

Council for 1957

President

Prof. P. S. Gill, M.S., Ph.D., F.A.P.S., F.N.I., F.N.A.SC., Aligarh.

Vice-Presidents

Prof. N. R. Dhar, D.SC., F.R.I.C., F.N.I., F.N.A.SC., Allahabad.
Prof. W. D. West, M.A., C.I.E., SC.D., F.A.S., F.N.I., F.N.A.SC., Saugor.

Honorary Treasurer

Prof. S. Ghosh, D.SC., F.R.I.C., F.N.I., F.N.A.SC., Allahabad.

Foreign Secretary

Dr. R. K. Saksena, D.SC., F.N.I., F.N.A.SC., Allahabad.

General Secretaries

Dr. R. N. Tandon, M.SC., PH.D., D.I.C., F.N.A.SC., Allahabad.
Shri S. Basu, M.SC., F.N.I., F.N.A.SC., New Delhi.

Members

Prof. P. L. Srivastava, M.A., D.Phil., F.N.I., F.N.A.SC., Allahabad.
Mrs. Savitri Sahni, M.SC., F.N.A.SC., Lucknow.
Prof. S. Ranjan, M.SC., D.SC., F.N.I., F.N.A.SC., Allahabad.
Prof. A. K. Bhattacharya, D.SC., F.R.I.C., F.N.A.SC., Saugor.
Prof. K. Banerji, D.SC., F.N.I., F.N.A.SC., Allahabad.
Prof. R. Misra, M.SC., PH.D., F.N.I., F.N.A.SC., Banaras.
Prof. M. D. L. Srivastava, D.SC., F.N.A.SC., Allahabad.
Shri M. S. Randhawa, M.SC., F.N.I., F.N.A.SC., I.C.S., New Delhi.
Prof. H. R. Mehra, M.SC., PH.D., F.N.I., F.N.A.SC., Allahabad.

The Proceedings of the National Academy of Sciences, India, is published in two sections: Section—A (Physical Sciences) and Section—B (Biological Sciences). Six parts of each section are published annually.

The Editorial Board in its work of examining papers received for publication is assisted, in an honorary capacity, by a large number of distinguished scientists. Papers are accepted from members of the Academy *in good standing*. In case of a joint paper, one of the authors must be a member of the Academy. The Academy assumes no responsibility for the statements and opinions advanced by the authors. The papers must conform strictly to the rules for publication of papers in the *Proceedings*. A total of 50 reprints are supplied free of cost to the author or authors. The authors may have any reasonable number of additional reprints at cost price, provided they give prior intimation while returning the proof.

Communications regarding contributions for publication in the *Proceedings*, books for review, subscriptions, etc., should be sent to the General Secretary, The National Academy of Sciences, India, Lajpatrai Road, Allahabad-2 (India).

Annual Subscription for each Section: Rs. 30 (Inland); 60 sh. (Foreign)
Single Copy: Rs. 5 (Inland); 10 sh. (Foreign).

PROCEEDINGS
OF THE
NATIONAL ACADEMY OF SCIENCES
INDIA
1957

PART VI] *SECTION A* [VOL. XXVI

SYMPOSIUM ON CONSTITUTION OF STARS: PRESIDENTIAL ADDRESS

BY PROF. A. C. BANERJI
(*Vice-Chancellor, University of Allahabad*)

Delivered at the Silver Jubilee Session of the Academy held at the University of Lucknow on December 28, 1955

THE constitution of stars, especially the Main Sequence stars, has been well investigated. A star in radiative equilibrium with uniform composition and with or without any convective core is analysed completely when chemical composition, the equation of state, the opacity law and energy generation are known. While hydrogen and helium are the main constituents, other elements are important, and the opacity follows from the contribution of the 'Oxygen group' towards lesser opacity, and the 'Iron group' towards higher opacity, and the energy generation is largely regulated by the Carbon-Nitrogen Cycle.

The radius and luminosity are two observables for a star of known mass. In eclipsing binaries with apsidal motion, the control density concentration is determinable. The uniformity or otherwise by mixing in a convective zone, and the existence of isothermal cores with all hydrogen exhausted can be studied indirectly.

For white dwarfs use of relativistic degeneracy has clarified some aspects. For red giants and their central condensation, not very much is known, and the energy generation may follow from the Carbon-Nitrogen Cycle for large

condensation, and Li, Be or B reactions for moderate condensation while little is known for supergiants.

Among numerous cosmogenic problems, reference may be made to magnetic fields in rotating stars, ultimate exhaustion of hydrogen in the main sequence stars, the continued existence of supergiants in a comparatively old universe and the evolution of white dwarfs.

STELLAR MODELS

For the sun, Epstien's model taking both P.P. and C.N. generation and free-free opacity leads to 6–7% He, $\rho_c = 98$ gm./cm. and $T_c = 10^{7°} - 3 \times 10^{7°}$ C.

Bierman's findings in 1938 lead to convective instability proceeding far into the interior in case the temperature gradient approximates to the adiabatic gradine in the convective zone in the solar photosphere or bleow. Epstien indicates a convective core covering 8% of the solar radius, which is smaller than that deducible from the P.P. reaction.

When H_2 forms 40% or more of the material, the luminosity determines the lifespan, which for the sun would be above 50×10^9 years. This is on the higher side, as stars in the higher luminosity stage have shorter lifespan.

This would be of the order of 10^9 years for stars of zero magnitude in the Russel Hertzsprung diagram from where the two branches of " Swollen up " stars and the " shrunken " stars shoot off.

Of the three possible solutions of a stellar model with an isothermal core, and a radiative envelope, one leads to large radii usual in red giants, and the other two to normal stars. For large cores, a pressure inversion may lead to non-stationary on even pulsating models.

Hoyle's model supposes high percentage of H_2 initially, synthesising into heavier elements with time, and a final collapse into white dwarfs.

Reference may be made to various stellar models by Hoyle and Lyttleton Bondi, Tulenkora and Mat Veem, Emin-Zale and others. In the model of Schwarzschild and others, with partially degenerated and exhausted cores, and boundary discontinuity, large radii typical of red giants are obtained for the case of one-third mass concentrated at the core.

WHITE DWARFS

Sorokni, Chandrasekharan and others have investigated models for White Dwarfs. Sorokni used different degrees of degeneracy in isothermal gas spheres and considered the pressures due to ions and the degenerate

election. In Schatzmann's model with a heavy element core and hydrogen mantle, there was a balance between generation and emission of energy. Mestel indicated the tendency towards explosion if subatomic energy source is additionally present. The resulting dynamical and vibrational instability was studied by Hedoux and Sauvenir-Gottin.

Red Giants

Chemical inhomogeneities from hydrogen exhaustion in the core and accretion in the envelope explain many features, and the largest radii are indicated when the helium core and hydrogen envelope have about equal masses. Interesting models were constructed by Mlle. Gardner with suitable values for M.R.L. and variation in composition.

Pulsations of Stars

Variation in luminosity, radii and polytropic indices, and temperature dependence on vibrational stability and other features have been treated by Ledonox, Schatzmann and others. Non-radial pulsation with or without stellar rotations involve fourth order equations of which suitable solutions are difficult, and no satisfactory comparison are available. On non-stationary stars, the question of nuclear explosion, the outward propagation of the waves, Schatzmann referred to He^3 reactions. Curevitch referred to accretion of deuterium-rich material, which if sufficiently swift would lead to supernovæ, and Sedov referred to alternatives possible in nuclear explosion.

Stellar Evolution

Greenstein proposed a classification into (*a*) Wolf-Rayel Stars, (*b*) He and C stars deficient in H_2, (*c*) Hot Sub-Dwarfs, (*d*) White Dwarfs, (*e*) High velocity stars and (*f*) S stars. Mme. Masevitch covered the evolution under Parenogo's theory for Main sequence and sub-giant range. Various suggestions for evolutionary stages were made by Schatzmann, Sandage, Hoyle, Kopal, Schwarzschild and others. The effects of rotations on luminosity and possible intermixing were considered by Sweet, Oke, Greenstein and others.

Magnetic stars discovered by Babcock have received considerable attention, and the requirements of magnetic energy, effects on stellar stability, and decay of pulsations have been considered by Mlle. Gjellestad, Fefforn, Memory, Chandrasekhar, Lermi, Wruvel and others.

Generation of Stars

Reference may be made to Hoyle's suggestion of Stellar formation from diffuse clouds by contraction and gravitational instability, Lebedinsky's

suggestion of interaction of stars with diffuse materials and fission beyond critical masses, Krat's suggestion of initially comet-like bodies, and Ambartsumian's suggestion of pre-stellar 'proto star' followed by an expanding universe. Parenago indicated a good theoretical luminosity distribution by postulating that new stars entered the main sequence near special class O, and proceeding subsequently with decreasing mass. Kaplan however indicated that about 80% of the young stars, entering at different spots, should have 6 to 18×solar mass, and special type 09–B4.

There have been useful investigation by Mestal on factors involving corpuscular emission from the sun, by Bondi on the limiting of accretion due to sonic speed and by Mertil on the early formation of large spherically symmetrical accretion due to slowing down of the motion of the star relative to the cloud, and the importance of rapid accretion relative to heating effects of radiation.

Thus Stellar evolution would continue to maintain for a long time to come a prodominant place in human thought and aspiration after an understanding of the universe.

EXCHANGE POTENTIAL AND THE MASS-RADIUS RELATION FOR COLD BODIES

BY PYARE LAL AND P. L. BHATNAGAR

(University of Delhi)

Read at the Silver Jubilee Session of the Academy held at the University of Lucknow on December 28, 1955

ABSTRACT

Kothari used his theory of pressure-ionization to obtain the maximum radius for the cold bodies. In his investigations he neglected the exchange potential term. Ramsey on this account criticised Kothari's theory and stressed the importance of the exchange term. The present paper is an attempt to take into account the effect assuming that the planets are made of iron.

The effect of taking the exchange potential into consideration is to reduce the pressure for a given density and thus increase the normal density at zero pressure from 63–87 gm./c.c. A graph exhibiting the pressure-density relation has been drawn and for comparison the graph denoting this relationship without exchange potential has also been given. Similarly the degree of ionization for a given density is also found to be less in the present case than what it would be if the effect is neglected. Finally, the mass-radius relation for cold bodies taking exchange potential is obtained in the form of a curve. In obtaining the relationship the results of numerical integrations performed by Auluck have been used with necessary modification. The effect of exchange term is to reduce for a given mass the radius from what it would be if this correction is neglected. Thus the inclusion of the exchange potential term produces a greater divergence from the observational data for terrestrial planets. In conclusion, it may be mentioned that the exchange potential term produces a slight reduction (5·6%) in the maximum radius for a cold body.

1. KOTHARI (1938) studied the mass-radius relationship of cold bodies on the basis of the theory of pressure ionization. In his investigation he neglected the effect of exchange potential term. Ramsey (1948, 1950, 1951) stressed the importance of the exchange term.

We shall approximately investigate here the effect of adding the exchange potential term in the expression for total energy of a degenerate gas. In the numerical work we will be taking the cold bodies to be composed of metal iron. The detailed calculations for effect on iron and hydrogen are in progress and will be published shortly.

2. Dirac (1930) showed that the exchange potential acting on an electron of momentum P and co-ordinate Q immersed in a sea of electrons is:

$$A(Q, P) = \frac{e^2}{2\pi^2 h} \int \frac{\rho(Q, P')}{|P - P'|^2} dP', \tag{1}$$

where $\rho(Q, P')$ is the density of electrons in phase space. At zero temperature he found that

$$A(Q, P) = -e^2 (4P_0/h) F(\eta), \tag{2}$$

where

$$F(\eta) = \tfrac{1}{2} + \frac{1 - \eta^2}{4\eta} \log \frac{1 + \eta}{1 - \eta} \tag{3}$$

and

$$\eta = \frac{P}{P_0} \tag{3 a}$$

P_0 being the momentum of the electron at the top of Fermi band.

Slater (1951) suggested that we may use this result to produce a good approximation to the exchange term in the Hartree-Fock equation by averaging over the momentum P of the various electrons. This gives

$$-3e^2 \left(\frac{3n}{8\pi}\right)^{\frac{1}{3}} \tag{4}$$

as the exchange potential energy *per electron.*

3. As usual the pressure-density relation will be determined from the Virial Theorem

$$3pv = 2T + W \tag{5}$$

T being the kinetic energy, W the total potential energy per cell, v volume of the cell and p the external pressure. This theorem is valid when the particles are assumed to be interacting according to the inverse square law of distance. We consider the material divided into spherical cells, each containing a nucleus of charge Ze at the centre and Z electrons distributed in the cell of radius

$$a = \left(\frac{\gamma_1 A m_H}{\rho}\right)^{\frac{1}{3}}, \tag{6}$$

where m_H is the mass of the hydrogen atom, A and ρ are atomic weight and density of the material considered and γ_1 a factor of the order of unity depending mostly on lattice structure.

4. *Pressure-ionization*:—The kinetic energy of a degenerate gas at zero temperature is given by the usual relation:

$$E_0 = \frac{3}{10}\frac{h^2}{m}\left(\frac{3n^*}{8\pi}\right)^{\frac{2}{3}} \cdot N \qquad (7)$$

where n^* is the total electron concentration and N the total number of electrons in a cell.

We take

$$n^* = \frac{Z}{\gamma_2 a^3}, \qquad (8)$$

γ_2 being a factor of the order of unity.

Substituting in equation (7) the value of N and n^* we get the kinetic energy per cell as:

$$T' = \frac{3}{10}\frac{h^2}{m}\left(\frac{3}{8\pi}\frac{Z\rho}{\gamma_1\gamma_2 A m_H}\right)^{\frac{2}{3}} Z, \qquad (9)$$

and the total kinetic energy as:

$$T = \frac{3}{10}\frac{h^2}{m}\left(\frac{3}{8\pi}\frac{Z\rho}{\gamma_1\gamma_2 A m_H}\right)^{\frac{2}{3}} \cdot Z \cdot \frac{\rho V}{A m_H} \qquad (9\,a)$$

$\rho V/Am_H$ being the number of cells in volume V.

The total potential energy W consists of two parts: W_P the electrostatic potential energy and W_E the exchange energy.

For W_P' the energy per cell we take the simple expression:

$$W_P' = -\int_0^a \frac{\left(Ze - \frac{4\pi}{3}x^3 n^* e\right)}{x} 4\pi x^2 n^* e\,dx$$

$$= -\frac{9}{10}\frac{Z^2e^2}{a}.$$

Substituting the value of a from equation (6)

$$W_P' = -\frac{9}{10}Z^2e^2\left(\frac{\rho}{\gamma_1 A m_H}\right)^{\frac{1}{3}} \qquad (10)$$

and the total electrostatic energy as:

$$W_P = -\frac{9}{10}Z^2e^2\left(\frac{\rho}{\gamma_1 A m_H}\right)^{\frac{1}{3}} \cdot \frac{\rho V}{A m_H} \qquad (10\,a)$$

From Slater's expression (4) we find that the exchange energy W_E' per cell is given by:

$$W_E' = -3e^2\left(\frac{9}{32\pi^2}\frac{Z\rho}{\gamma_1 A m_H}\right)^{\frac{1}{3}} Z \tag{11}$$

and the total exchange energy as

$$W_E = -3e^2\left(\frac{9}{32\pi^2}\frac{Z\rho}{\gamma_1 A m_H}\right)^{\frac{1}{3}} Z \cdot \frac{\rho V}{A m_H} \tag{11 a}$$

For the sake of simplicity we will be putting γ_1 and γ_2 each equal to unity.

From (10 *a*) and (11 *a*) we find

$$\frac{W_E}{W_P} = \frac{5}{(12\pi^2)^{\frac{1}{3}}}\frac{1}{Z}$$

$$= 1{\cdot}018145 \quad \text{for hydrogen}$$

$$= 0{\cdot}116010 \quad \text{for iron.}$$

Thus the contribution of exchange potential energy amount to 101·815% in case of hydrogen and 11·601% in the case of iron of the electrostatic potential energy. In passing we note that in (11 *a*) the power of Z is $-\frac{2}{3}$ and not $-5/3$ as obtained by Vardya (1955). This difference arises on account of his taking $-3e^2(3n/8\pi)^{\frac{1}{3}}$ as the exchange energy per cell in place of per electron. We give the values of the energy T', W_P', W_E' for different densities in Table I (Appendix).

Substituting the value of T, W_P and W_E from equations (9 *a*), (10 *a*) and (11 *a*) in equation (5) we get the pressure density relation as:

$$p = K\rho^{5/3}\left[1 - \left(\frac{\Delta AZ}{\rho}\right)^{\frac{1}{3}}\eta\right] \tag{12}$$

where

$$K = \frac{8\pi}{15}\frac{h^2}{m}\left(\frac{3Z}{8\pi A m_H}\right)^{5/3}$$

$$\Delta = \left[2.3^{\frac{1}{3}}.\pi^{\frac{2}{3}}.m.m_H^{\frac{1}{3}}\frac{e^2}{h^2}\right]^3$$

and

$$\eta = 1 + \frac{5}{(12\pi^2 Z^2)^{\frac{1}{3}}}.$$

In Fig. 1 the continuous curve gives the plot of $\log p$ against $\log \rho$ as obtained here for iron, the dotted curve gives the relation when $\eta = 1$,

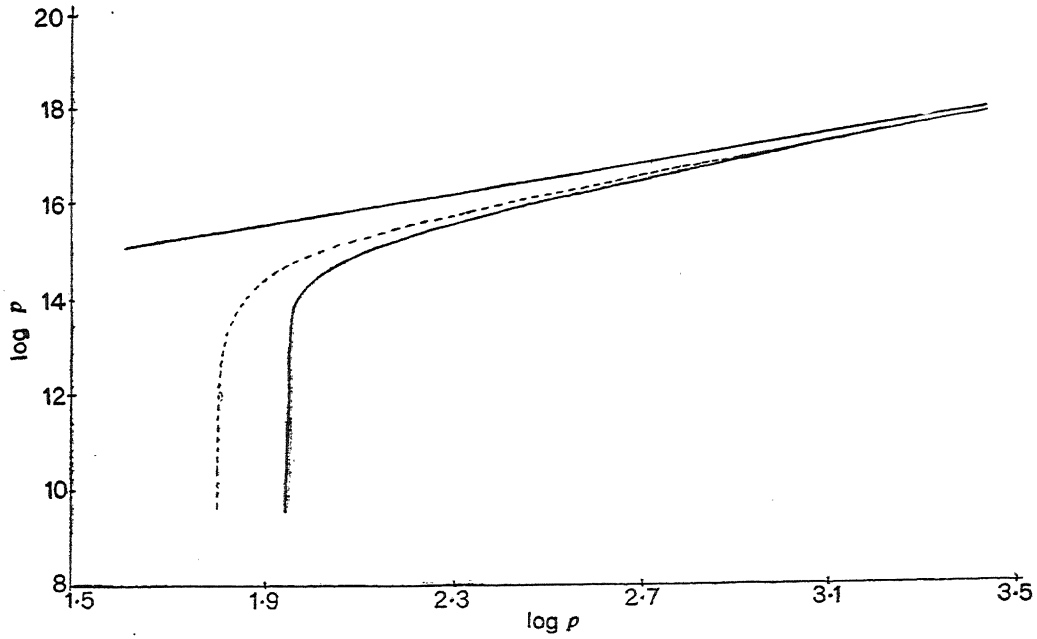


FIG. 1

i.e., when exchange potential is neglected as in Kothari's theory and the straight line gives the relation at complete ionization.

Following Jensen (1938) we express the pressure in units of pressure $\bar{p}$ resulting from a uniform distribution of electrons of the material throughout the available volume, *i.e.*,

$$p = \bar{p} f^{5/3} \tag{13}$$

where

$$\bar{p} = \frac{8\pi}{15}\frac{h^2}{m}\left(\frac{3Z\rho}{8\pi A m_H}\right)^{5/3} \tag{14}$$

$$f = \left[1 - K'\frac{\eta}{\rho^{\frac{1}{3}}}\right]^{3/5} \tag{15}$$

and

$$K' = (\Delta AZ)^{\frac{1}{3}} \tag{16}$$

f stands for r/Z in Kothari's theory of ionization (1938), where r is the degree of ionization of the material.

In Table II (Appendix) are given values of log f for different values of log ρ. f_1 corresponds to the case $\eta = 1$ and f_2 to the present case when $\eta = 1 + 5/(12\pi^2 Z^2)^{\frac{1}{3}}$.

5. *Mass-radius relation:—(i) Approximate treatment* using mean value of f. In this case the pressure-density equations (13) and (14) correspond to the polytropic relation with index.

The mean density of a spherical aggregate of matter of mass M and the radius R is given by

$$\bar{\rho} = \frac{3M}{4\pi R^3} \tag{17}$$

and the radius R is related to mass M through the solution of Emden equation for index 3/2 as given by Milne (1932).

$$R = lf^{5/3}\left(\frac{\odot}{M}\right)^{\frac{1}{3}} \tag{18}$$

where

$$l = \frac{5\,(w^{\circ}_{3/2})^{\frac{1}{3}} \cdot K}{2^{7/3}\pi^{\frac{2}{3}} G \cdot \odot^{\frac{1}{3}}}\left(\frac{Z}{A}\right)^{5/3}.$$

For approximate calculations we take $\rho = \bar{\rho}$ in (15) and then substituting for $\bar{\rho}$ from (17) and using the value of f thus obtained in (18), we get:

$$R = \frac{l\left(\frac{\odot}{M}\right)^{\frac{1}{3}}}{1 + K_1 l\eta\left(\frac{\odot}{M}\right)^{\frac{2}{3}}} \tag{19}$$

where

$$K_1 = \left(\frac{4\pi}{3\odot}\right)^{\frac{1}{3}} \cdot (\Delta AZ)^{\frac{1}{3}}.$$

We shall denote the value of R for $\eta = 1 + 5/(12\pi^2 Z^2)^{\frac{1}{3}}$ by R′ and its value for $\eta = 1$ by R″. We have tabulated R′ and R″ for various values of $M/\odot$ in Table IV.

From (17) and (18) we can express R and M in terms of $\bar{\rho}$ and f:

$$R = \left[\frac{3\odot l^3}{4\pi}\right] \frac{f^{5/6}}{\bar{\rho}^{\frac{1}{2}}} \tag{20}$$

and

$$M = \left[\frac{4\pi\odot}{3} l^3\right]^{\frac{1}{2}} \cdot f^{5/2} \cdot \bar{\rho}^{\frac{1}{2}}. \tag{21}$$

Taking logrithmic differentiation we have

$$\frac{d\mathrm{R}}{\mathrm{R}} = \frac{5}{6}\frac{df}{f} - \frac{1}{6}\frac{d\bar{\rho}}{\bar{\rho}}$$

and

$$\frac{d\mathrm{M}}{\mathrm{M}} = \frac{5}{2}\frac{df}{f} + \frac{1}{2}\frac{d\bar{\rho}}{\bar{\rho}}.$$

Dividing sidewise and putting $d\mathrm{R}/d\mathrm{M} = 0$ for maximum radius with reference to M, we have

$$5\frac{df}{f} = \frac{d\rho}{\bar{\rho}}$$

i.e.,

$$\frac{d\log f^{5/3}}{d\log \rho^{\frac{1}{3}}} = 1.$$

In Fig. 2 we have plotted $\log f^{5/3}$ against $\log \rho^{1/3}$ using (15). The continuous curve is for the present case and the dotted one for $\eta = 1$. The point of contact of tangent of slope 1 determining the values of f and $\bar{\rho}$ for which the radius is maximum. The order of change in the values of f and $\bar{\rho}$ for maximum radius as brought about by taking into consideration the exchange term, is exhibited by this graph.

(19) gives the maximum radius for:

$$\frac{\mathrm{M}}{\odot} = (\mathrm{K}_1\eta l)^{3/2}$$

So that

$$\mathrm{R}_{\max} = \tfrac{1}{2}\left(\frac{l}{\mathrm{K}_1\eta}\right)^{\frac{1}{2}}$$

Therefore

$$\frac{\mathrm{R}_{\max}(\eta)}{\mathrm{R}_{\max}(\eta = 1)} = \frac{1}{\eta^{\frac{1}{2}}}$$

$$= \frac{1}{\left\{1 + \frac{5}{(12\pi^2\mathrm{Z}^2)^{\frac{1}{3}}}\right\}^{\frac{1}{2}}}$$

$$= \cdot 7039 \text{ for hydrogen}$$

$$= \cdot 9466 \text{ for iron.}$$

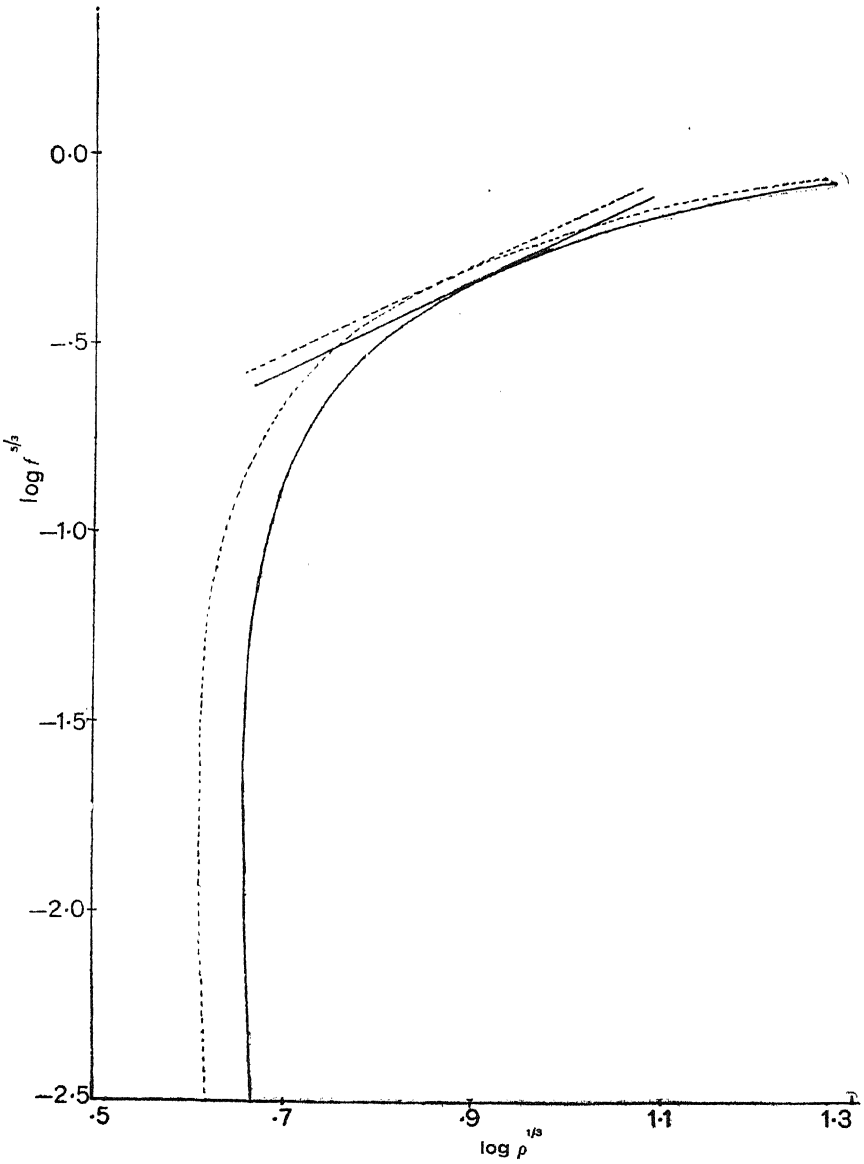


FIG. 2

(*ii*) *Exact treatment.*—We take equation (12) in the form

$$p = K\rho^{5/3}\left[1 - \frac{\bar{K}}{\rho^{\frac{1}{3}}}\right] \tag{22}$$

where

$$\bar{K} = (\Delta AZ)^{\frac{1}{3}} \cdot \eta = K'\eta.$$

The equations determining the mechanical equilibrium are:

$$\frac{dp}{dr} = -\rho \frac{M(r)}{r^2} G \tag{23}$$

and

$$\frac{dM}{dr} = 4\pi r^2 \rho, \tag{24}$$

where the pressure-density relation is given by (22).

Following Auluck (1939), we introduce the new variables z and x defined by:

$$p = \left(\frac{4\bar{K}}{5} z\right)^3 \tag{25}$$

$$r = \frac{5}{4}\left(\frac{K}{\pi G \bar{K}}\right)^{\frac{1}{2}} \cdot x \tag{26}$$

We may note that in place of his K′ we are using $\bar{K} = K'\eta$, where η has been introduced in (22) to take account of the exchange energy.

On using (25) and (26) in (17), (18) and (19), we get

$$\frac{1}{x^2}\frac{d}{dx}\left\{x^2 (z-1)\frac{dz}{dx}\right\} + z^3 = 0 \tag{27}$$

$$M(r) = -4\pi \left(\frac{K\bar{K}}{\pi G}\right)^{3/2} x^2 (z-1)\frac{dz}{dx}. \tag{28}$$

Let z_0 be the central value of z, then

$$z_0 = \frac{5}{4\bar{K}} \rho_c^{\frac{1}{3}}.$$

Equation (27) is to be integrated with the usual boundary conditions, namely

(*i*) at the centre: $x = 0$, $z = z_0$ and $dz/dx = 0$

(*ii*) at the surface: $p \to 0$ and hence $z \to 5/4$.

The radius R and mass M of the configuration will be given by:

$$R = \frac{5}{4}\left(\frac{K}{\pi G \bar{K}}\right)^{\frac{1}{2}} x_1 \tag{29}$$

$$M = 4\pi \left(\frac{K\bar{K}}{\pi G}\right)^{3/2} v_1, \tag{30}$$

where x_1 is the value of x corresponding to $z = 5/4$ (the boundary value) and v_1 is the value of $\{-x^2(z-1)\,dz/dx\}$ for $x = x_1$.

We shall use here the results of numerical integrations carried out by Auluck (*loc. cit.*) and hence we collect in Table III (Appendix) the values of x_1 and v_1 as obtained by him.

The values of R and $M/\odot$ for the present case when $\eta = 1 + 5/(12\pi^2Z^2)^{\frac{1}{3}}$ are given in Table IV (Appendix).

A glance at Table IV shows that the values of R′ obtained by using mean value of f are in agreement with the corresponding values of R obtained by numerical integration for the actual value of f for small and large values of $M/\odot$, but differ by about 2% in the small range about the maximum radius.

To exhibit the change in the radius as brought about by taking the exchange energy into consideration, we plot log R against log $M/\odot$ in Fig. 3. The continuous curve is for the present case when exchange

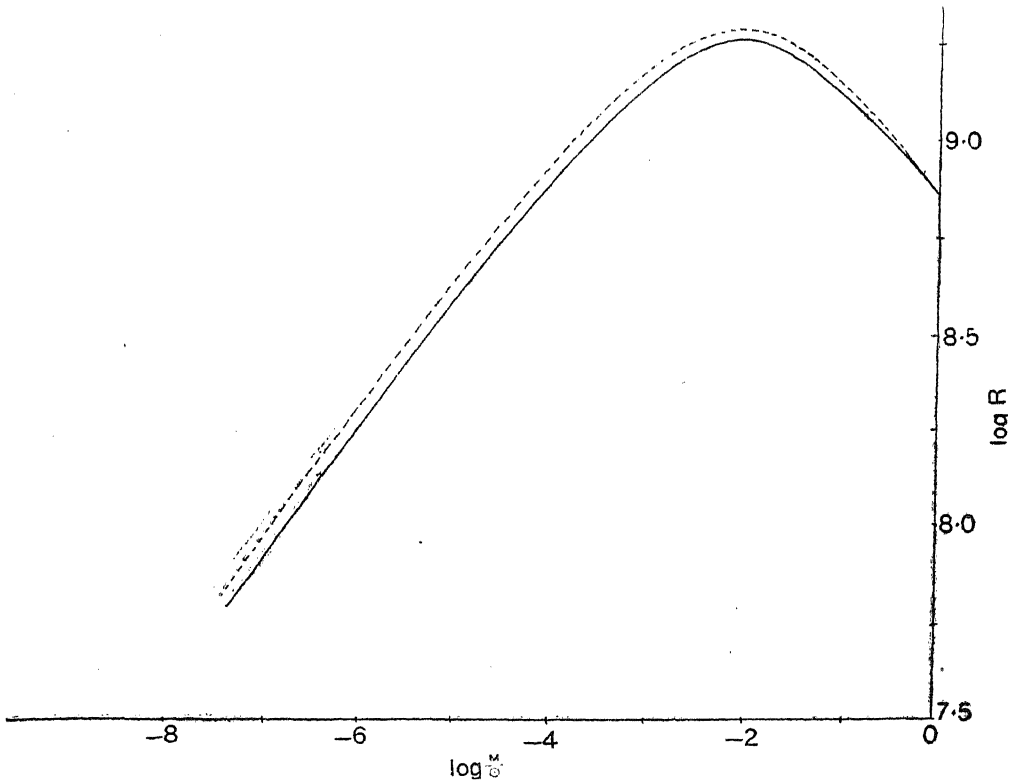


FIG. 3

energy is taken into consideration and the dotted one for the case when exchange energy is not taken into consideration.

From the graph we conclude that the effect of taking the exchange energy into consideration is to reduce the radius for a given mass by a small fraction. We give below the percentage of reduction for the mass corresponding to various bodies in Table V (Appendix). The values of $R(\eta)$ and $R(\eta = 1)$ have been obtained by interpolation from Table IV and the values obtained by Auluck (*loc. cit.*). We find that the effect of the exchange potential term is to reduce the radius for a given mass and thus produce a greater divergence from the observational data for terrestrial planets.

The reduction in the maximum radius on account of taking the exchange energy into consideration amounts to about 5·6%.

References

1. Auluck, F. C., 1939, "The theory of pressure-ionization and the constitution of white dwarf stars," *Mon. Not., R.A.S.*, **99**, 239–47.
2. Dirac, P. A. M., 1930, "Note on exchange phenomena in the Thomas atom," *Proc. Comb. Phil. Soc.*, **26**, 376–87.
3. Kothari, D. S., 1938, "The theory of pressure-ionization and its applications," *Proc. Roy. Soc.*, **165 A**, 486–500.
4. Milne, E. A., 1932, "The problem of stellar structure," *Mon. Not., R.A.S.*, **92**, 611–43.
5. Ramsey, W. H., 1948, "On the constitution of the terrestrial planets," *ibid.*, **108**, 406–16.
6. ———, 1950, "The planets and the white dwarfs," *ibid.*, **110**, 444–54.
7. ———, 1951, "On the constitution of major planets," *ibid.*, **111**, 427–47.
8. Slater, J. C., 1951, "A simplification of the Hartree-Fock method," *Phys. Rev.*, **81**, 385–90.

APPENDIX

TABLE I

$\log \rho$	$T' \times 10^8$	$W'_P \times 10^8$	$W_E' \times 10^8$	$(2T'+W'_P) \times 10^8$	$(2T'+W'_P+W'_E) \times$
1·799785	·615387	—1·230773	—·142782	·000001	—·142781
1·799811	·615412	—1·230797	—·142784	·000027	—·142757
1·800671	·616225	—1·231611	—·142887	·000839	—·142048
1·942790	·766452	—1·373555	—·159346	·159349	·000003
1·942816	·766483	—1·373582	—·159349	·159384	·000035
1·942979	·766675	—1·373754	—·159369	·159596	·000227
1·943676	·767495	—1·374490	—·159454	·160500	·001046
1·945597	·769763	—1·376520	—·159690	·163006	·003316
1·951694	·77700	—1·38298	—·16044	·17102	·01058
1·971464	·80057	—1·40380	—·16285	·19735	·03450
2·034720	·88262	—1·47397	—·17100	·29126	·12026
2·149604	1·05284	—1·60985	—·18676	·49583	·30907
2·438053	1·63931	—2·00874	—·23304	1·26988	1·03684
3·432608	7·54566	—4·30975	—·49997	10·78157	10·28160

TABLE II

$\log \rho$	$\log f_1$	$\log f_2$
1·799785	$\bar{4}$·500000	×
1·799811	$\bar{3}$·20000	×
1·800671	$\bar{2}$·10000	×
1·942790	$\bar{1}$·410097	$\bar{4}$·50000
1·942816	$\bar{1}$·410125	$\bar{3}$·20000
1·942979	$\bar{1}$·410425	$\bar{3}$·70000
1·943676	$\bar{1}$·411622	$\bar{2}$·100000
1·945597	$\bar{1}$·414891	$\bar{2}$·400000
1·951694	$\bar{1}$·424966	$\bar{2}$·700000
1·971164	$\bar{1}$·454484	$\bar{1}$·000000
2·034720	$\bar{1}$·530481	$\bar{1}$·300000
2·149604	$\bar{1}$·623165	$\bar{1}$·500000
2·438053	$\bar{1}$·752833	$\bar{1}$·700000
3·432608	$\bar{1}$·912373	$\bar{1}$·900000

TABLE III

Z_0	x_1	v_1
1000	·0818	$3·01\times10^{4}$
500	·1154	$1·07\times10^{4}$
100	·2545	937
10	·6939	23·6
4	·8400	3·84
3	·8239	1·84
2	·6838	·449
1·5	·4293	$6·59\times10^{-2}$
1·35	·2792	$1·56\times10^{-2}$
1·3	·1971	$5·23\times10^{-3}$
1·26	·0878	$4·44\times10^{-4}$
1·255	·0620	$1·56\times10^{-4}$
1·251	·0277	$1·39\times10^{-5}$

TABLE IV

$\log \frac{M}{\odot}$	log R	log R′	log R″
0·42761	8·73981	8·73989	8·74091
$\bar{2}$·82878	9·17542	9·17947	9·18931
$\bar{2}$·04020	9·25840	9·26669	9·28863
$\bar{3}$·72069	9·25000	9·25925	9·28699
$\bar{3}$·10812	9·16905	9·17808	9·21530
$\bar{4}$·27476	8·96688	8·97160	9·01581
$\bar{5}$·64900	8·78004	8·78185	8·82814
$\bar{5}$·17437	8·62881	8·62987	8·67686
$\bar{6}$·10325	8·27762	8·27757	8·32512
$\bar{7}$·64900	8·12651	8·12672	8·17433
$\bar{8}$·59889	7·77660	7·77714	7·82480

TABLE V

	$\log \frac{M}{\odot}$	log R (Actual)	log R (η)	log R ($\eta=1$)	$\frac{R(\eta=1)-R(\eta)}{R(\eta=1)} \times 100$
Moon ..	$\bar{8}$·558	8·2401	7·7626	7·8106	11·7
Mercury ..	$\bar{7}$·081	8·3827	7·9375	7·9850	11·6
Mars ..	$\bar{7}$·520	8·5758	8·0837	8·1312	11·6
Venus ..	$\bar{6}$·387	8·7864	8·3714	8·4187	115
Earth ..	$\bar{6}$·479	8·8047	8·4017	8·4490	11·5
Uranus ..	$\bar{5}$·646	9·3956	8·7791	8·8250	11·2
Neptune ..	$\bar{5}$·714	9·4241	8·7991	8·8433	10·7
Saturn ..	$\bar{4}$·456	9·7812	9·0171	9·0600	10·4
Jupiter ..	$\bar{4}$·980	9·8535	9·1436	9·1840	9·8
O_2 Eridani B ..	$\bar{1}$·644	9·1020	8·9981	9·0019	0·9
Sirius B ..	$\bar{1}$·982	9·1320	8·8973	8·8975	0·15

METHOD OF SEPARATION (IN ASTROPHYSICAL PROBLEMS)

BY G. BANDYOPADHYAY

(Indian Institute of Technology, Kharagpur)

Read at the Silver Jubilee Session of the Academy held at the University of Lucknow on December 28, 1955

THE object of this note is to show the importance of a lemma in astrophysical problems.

A contracting, expanding or vibrating star may be looked upon as a spherical mass of gravitating gas in which heat exchange is going on through radiation and in which there are heat sources. This heat source is one due to the subatomic energy generation like proton-proton interaction or carbon cycle. The heat generation due to contraction is taken account of automatically when we consider the motion within the star.

With such a model the equations turn out to be

$$\ddot{r} = -4\pi r^2 \frac{\partial P}{\partial m} - \frac{Gm}{r^2}$$

$$4\pi r^2 \rho \frac{\partial r}{\partial m} = 1.$$

$$T\frac{dS}{dt} = -\frac{\partial}{\partial m}\left(-\frac{16\pi^2 ac}{3K} r^4 \frac{\partial T^4}{\partial m}\right) + \epsilon$$

$$\epsilon = C\rho^{\alpha}T^{\beta}$$

$$K = k\rho^{\lambda}T^{\mu}$$

where G is the gravitational constant, m is the mass enclosed within a sphere of radius r, S, the entropy and ϵ is the subatomic energy generation.

These equations are written on the assumption that opacity and generation obey power law.

The equations are non-linear in character and no well-known general solution exists in terms of arbitrary functions. The method, therefore, is to try certain special types of solutions of which an obvious case is to try a solution by method of variable separation. This method has been attempted by many writers (*e.g.*, Thomas, 1930) but even then a separation is not always possible and as such Thomas had to drop the question of energy

generation in his investigation of homogeneous models. Assumption of separable solution

$$r = r_0(m) f(t)$$

led Thomas to relations

$$\rho = \frac{\rho_1}{f^3}, \quad \mathrm{T} = \frac{\mathrm{T}_0}{f}, \quad \mathrm{P} = \frac{\mathrm{P}_0}{f^4}$$

by virtue of continuity equation and equation of motion if acceleration be neglected.

Substituting in energy equation we get

$$3\left(\mathrm{C}_p - \frac{4}{3}\mathrm{C}_v\right)\frac{\mathrm{T}_0}{f} = \frac{1}{f^\lambda}\frac{d}{dm}\left(\frac{16\pi^2 ac}{3}\frac{r_0^4}{k_0}\cdot\frac{d\mathrm{T}_0^4}{dm}\right) + \frac{\epsilon_0}{f^\mu},$$

which separates by the usual rule when $\epsilon = 0$. When $\epsilon \neq 0$ the separation of above equation has been found possible by virtue of the

LEMMA: If

$$\phi_1(y) f_1(x) + \phi_2(y) f_2(x) + \phi_3(y) f_3(x) = 0.$$

Then

either

$$f_1 = \mathrm{A} f_2 = \mathrm{B} f_3$$

and

$$\phi_1 + \frac{\phi_2}{\mathrm{A}} + \frac{\phi_3}{\mathrm{B}} = 0.$$

or

$$\phi_1 = \mathrm{C}\phi_2 = \mathrm{D}\phi_3,$$

and

$$f_1 + \frac{f_2}{\mathrm{C}} + \frac{f_3}{\mathrm{D}} = 0.$$

The proof of this lemma has been given earlier (Bandyopadhyay, 1948) assuming differentiability and a proof was also constructed without differentiability or even continuity.

This lemma has been used to obtain polytropic raidal motion of the stars where ϵ has not been neglected (Gupta, 1956).

The possibilities involved in the investigation are more complex than the previous paper (Bandyopadhyay, 1948) and has led to a number of very interesting conclusions, *e.g.*, homologous motion of a gas sphere with a polytropic relation between pressure and density is possible if opacity k and energy generation ϵ satisfy certain relations. The gas sphere in some of these cases will explode after a long time or collapse in finite time.

Again the gas sphere might have a character of vibration if $C_p/C_r > 4/3$ and the initial velocity satisfies certain condition. The distribution in this case is homogeneous and ϵ, k satisfy $\epsilon \alpha T^{\beta}$, $k \alpha T^{3-\beta}$.

References

1. Bandyopadhyay, 1948, *Proc. Nat. Inst. Sci., India*, **14**, 29–41.
2. Thomas, L. H., 1930, *M.N.R.A.S.*, **91**, 122–27.
3. Gupta, A. S., 1956 (Unpublished).

EVOLUTION OF STARS ON THE UPPER MAIN SEQUENCE

By R. S. Kushwaha

(Princeton University Observatory, Princeton, New Jersey)

Read at the Silver Jubilee Session of the Academy held at the University of Lucknow on December 28, 1955

It is quite natural to divide the Main Sequence into two parts, upper and lower, depending upon the following conditions:—

(*a*) In the upper part the main source of energy generation is the carbon cycle and in the lower one this part is played by the proton-proton reaction.

(*b*) The outer hydrogen convective zone is so narrow in the stars of Upper Main Sequence that a purely radiative envelope can be used for practical purposes while in the stars along the lower part we find a quite deep convective zone.

(*c*) The contribution of electron scattering to the opacity is predominant in the upper part but Kramer's opacity is the main factor for the lower part.

(*d*) For the equation of state the ideal gas law has to be augmented by radiation pressure in the former case while it is quite negligible in the latter.

The main object of the study of the stars on the Upper Main Sequence is to understand the H. R. diagrams of galactic clusters. Also it is here that a test of the theory of the stellar interior is provided by the observed apsidal motion of the Upper Main Sequence binaries. It is believed that the stars in their initial state, defined by a homogeneous model having the same chemical composition throughout, belong to the Main Sequence. We shall discuss here the construction of such initial models for three stars with mass 10, 5 and 2·5 times the solar mass and follow through the early phases of evolution, constructing 13 models in all.

In these stars there is one happy circumstance that the carbon cycle is very sensitive to temperature. As a result most of the energy is generated near the centre. Even at a small distance from the centre the energy flux produces a steep radiative temperature gradient, so much so that the gradient becomes unstable and convection occurs. Consequently our stars will have a convective core at the centre and a radiative envelope. The extent of the core is such that practically the whole energy generation takes place within the core, giving L_r constant in the envelope.

Assuming an initial composition as 90 per cent. Hydrogen, 9 per cent. Helium and 1 per cent. other heavier elements by mass and choosing the opacity so as to fit the present opacity tables as accurately as possible, we constructed the three homogeneous models. They are found to cover the range of spectral types from B_1 to A_2 and the run of central temperature from 28 to 20 million degrees. It is observed that the radiation pressure increases with increasing mass but is not very effective even for the heaviest of these masses. Electron scattering is found dominant in the interior of the heaviest star and is still quite important for even the lightest one. The mass fraction inside the core is about 25 per cent. for the heaviest and 16 per cent. for the lowest mass.

Comparing these models with the observations a reasonable agreement is found with the mass-luminosity relation. In the H-R diagram these stars fall a little to the left of the line representing the observational data. This discrepancy can be eliminated by a slight change in composition. Thus we find that these models represent satisfactorily the observed Upper Main Sequence.

To apply the apsidal motion test, the apsidal motion constants for these models have been computed. It is seen that the effective polytropic index n_{eff} increases with decreasing mass. This fact is in good agreement with the observations. The theoretical values are, however, somewhat lower than the average observed values (see table below). It is expected that this difference is caused by the fact that these are the initial models and subsequent evolution may explain it at least partially if not wholly. The satisfactory outcome of this test is very encouraging.

Stars	Y Cyg.	Gl Car.	AG Per.	RU Mon.	YY Sgr.	V_{523} Sgr.	Theoretical		
							10 M	5 M	2·5 M
Sp. typ. ..	O_9	B_3	B_{4-5}	B_9	A_0	A_5	B_1	B_{5-2}	A_{1-9}
n_{eff} ..	3·1	3·01	3·58	3·5	3·55	3·9	2·83	3·04	3·25

The effect of electron scattering really shows up when we follow the early evolutionary phases. In cases when electron scattering is negligible (stars on Lower Main Sequence) the mass inside the convective core remains the same throughout the early evolution but in these stars it decreases, that is, as the core recedes it leaves out continuously some layers which belonged to the core initially. Thus we have an intermediate zone of continuously

varying composition instead of a short discontinuity at the interface, as in the other case. Once a layer is left out of the core its composition will not change any more, at least during these phases considered here, since the total energy generation is confined to the core only. It is also obvious that the composition at any point in this zone will be a continuous function of the distance of the layer from the centre. Consequently our equations have to be modified for this region. Thus our evolutionary sequence of models will consist of a convective core which steadily decreases in mass, a radiative zone with variable composition which steadily increases in mass, and a homogeneous radiative envelope with fixed mass.

The computations were carried out for these models in all the three cases for certain values of the parameter of integration, the difference of which physically corresponds to the interval of time elapsed between the two models of the same star. Thus for every such step we add a new intermediate zone which is left out by the core during this interval of time.

During these phases the hydrogen in the core is depleted. Ultimately there comes a time when energy generation goes beyond the edge of the core, that is, the energy generated outside the core is no more negligible. From then onwards we have to take into account this generation in the intermediate zone also.

In addition the composition of these zones also varies with time. Hence to carry the evolution further we have to calculate this change of composition in every zone during a fixed step of interval of time, and modify our equations for the energy generation. This complicates the computational scheme very much as now we have three variable parameters to be determined by trial and error. These advanced models are in hand.

The evolutionary tracks of our three stars on the H. R. diagram are very similar in character to the ones obtained for Lower Main Sequence by Sandage and Schwarzschild.* The luminosity increases and the effective temperature decreases as the stars evolve, and the tracks turn from the Main Sequence to the right, pointing to the region of the red giants.

From the knowledge of luminosity and the rate of burning of hydrogen we can calculate the order of time the star has spent during these phases since the initial homogeneous models. It is found that this time comes out to be quite of the expected order of magnitude, around a billion years for the lightest mass and several ten million years for the heaviest one.

---

* Sandage, A. R., and Schwarzschild, M., 1952, *Ap. J.*, **116**, 463.

Thus the comparison between theory and the observations appears to be satisfactory. The case of AG Per, however, provides a discrepancy. If we interpret the binaries as Main Sequence stars in their early phases then this does not fit in. On one hand it belongs to the Perseus association, supposed to be only 1·3 million years old. On the other hand it shows apsidal motion which corresponds to quite advanced phases if we believe that the evolutionary effect will remove the discrepancy between the theory and the observations on the aspidal motion.

A POSSIBLE INTERPRETATION OF THE H-R DIAGRAM FOR THE PLEIADES BASED ON MODERN THEORY OF STELLAR STRUCTURE

By A. G. Massevitch

Moscow

Read at the Silver Jubilee Session of the Academy held at the University of Lucknow on December 28, 1955

Open stellar clusters are very important when developing a theory of the evolution of stars. The study of the Hertzsprung-Russell diagrams of clusters has a great advantage, as we deal here with a group of stars, which can with high probability be considered of the same origin. A comparison of the main features of the H-R diagrams for different clusters reveals new and interesting evolutionary trends, which may be of a general significance. One of the most intricate features is the tendency of the brightest cluster stars to " turn off " from the main sequence and up to the right. The position of the upper end of the main sequence varies, therefore, considerably from cluster to cluster.

In[1] we made an attempt to interpret the H-R diagrams for open stellar clusters on the basis of a theory of stellar evolution with corpuscular radiation.[2, 3] According to this theory we have to consider the first part of the main sequence, (from special type 0 till G4) of a cluster H-R diagram, as a result of evolution of initially unstable early-type stars, which become stable with time, owing to the loss of a part of their masses through corpuscular radiation. The process of conversion of hydrogen into helium, going on at the same time in the interiors of these stars, leads to a continuous increase of the mean molecular weight μ. The abundance of heavy elements (z) remains unchanged.

To obtain the evolutionary track for any star, and consequently the theoretical shape of the main sequence for a cluster, one has to solve two fundamental (L-M-R-μ)-relations, obtained from the theory of stellar structure together with the mass-luminosity relation, for the stars in question taking z = constant.

The equations are:

$$L = \text{const.} \frac{\mu^{4+\beta}}{K_0} M^{3+\beta+\alpha} R^{3\alpha-\beta} \qquad (1)$$

(This relation is obtained as a result of the construction of a semi-convective stellar model with an absorption law)

$$K = K_0 \rho^{\alpha} T^{-\beta}$$

$$L = \text{const.}\ \mu^{n} X Z M^{n+2} R^{-n-3} \qquad (2)$$

(This relation follows from the energy generation law $\epsilon = \epsilon_0 \rho T^n$, X being the abundance of hydrogen.)

The empirical mass-luminosity relation for the stars in question (0–G4) is[4].

$$L \sim M^{3.9} \qquad (3)$$

Evolutionary tracks, obtained from equations (1, 2, 3), represent (with appropriate values of Z) satisfactorily the main sequences of several well-known clusters [see[1]]. The observed different shapes of the main sequences for these clusters may then be interpreted as a result of evolution of groups of stars, which, having similar structure, differ in their initial compositions (characterized by the value of Z). This difference in Z is caused by the origin of stars belonging to different clusters in different parts of our Galaxy and probably by different ages.

In Fig. 1 we reproduce the H-R diagram of the Pleiades cluster with a theoretical main sequence for $z = 0{\cdot}10$. The observational data are taken from a paper by O. Eggen.[5] The theoretical curve is obtained from equations (1, 2, 3) with

$$K = K_0 \rho^{0.875} T^{-3.5}$$

and the carbon cycle as energy source. The stars are supposed to be well mixed, so that no difference between the molecular weights of the radiative envelope and the convective core has to be taken into account.

As may be seen from Fig. 1 the theoretical curve represents satisfactorily the main sequence of the Pleiades cluster except the upper end of it.

In our earlier work we tried to explain the " turn off " of the upper end of the main sequences in open clusters as a result of evolution of some of the hot stars, which, contrary to the main bulk of the cluster stars, evolve with constant mass. These stars were supposed to rotate slowly, so that corpuscular radiation plays but an insignificant role in their evolution. However, the hot stars of spectral type B6–B9 in the Pleiades cluster are almost entirely fast rotating stars[6] and show emission spectra, indicating intense corpuscular radiation.[7] These are the stars forming the upper end of the

main sequence of the Pleiades cluster. Thus it appears that our interpretation concerning this part of the H-R diagram has to be somewhat revised.

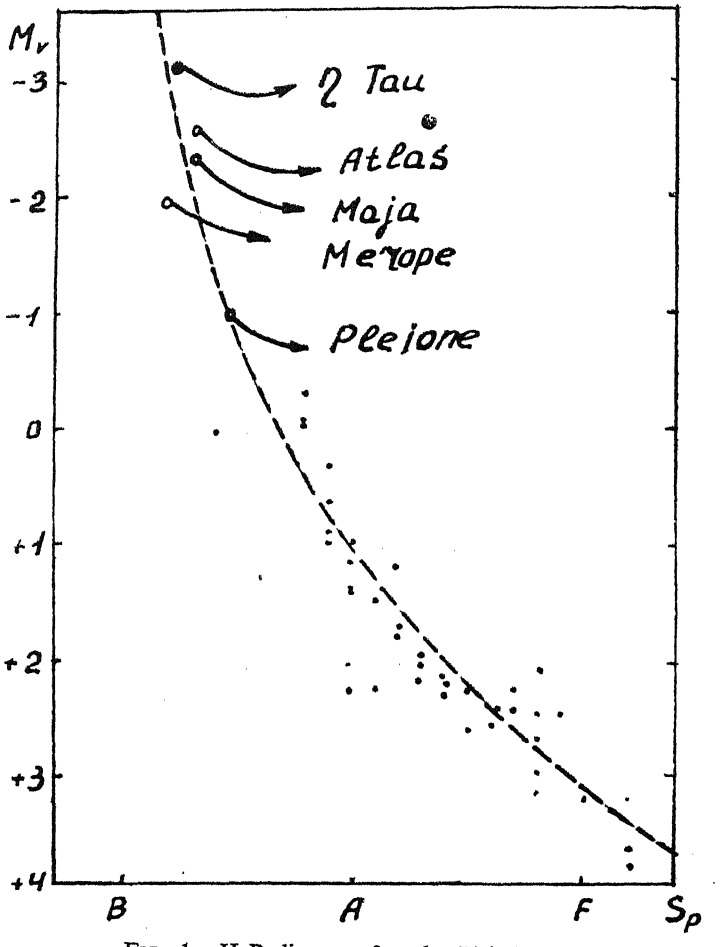


FIG. 1. H–R diagram for the Pleiades.

..... Evolution of mixed stars with decreasing mass.

——— Evolution of unmixed stars with decreasing mass.

→ Present position of the early type unmixed star.

O Initial position of the early type unmixed star.

We suggest that the main cause for some of the hot cluster star " branching off " the main seaquence is the absence of mixing between their envelopes and convective cores. An examination of possible evolutionary paths for mixed and unmixed stars[8] showed that an unmixed star always evolves up and to the right " off " the main sequence, not withstanding whether its mass decreases, or remains constant during the evolution.

Let us calculate the evolutionary tracks for 5 hot early type stars of the Pleijades, supposing that their masses decrease with time, but no mixing occurs between their envelope and convective cores. Here again we take the model with $K = K_0\rho^{0.875}$. The initial chemical composition is assumed to be: $X = 0{\cdot}90$, $z = 0{\cdot}10$. The characteristics of the stars in question will then be:

TABLE I

N	N of Eggen's list	M	Sp	*lg* L	*lg* R	*lg* M	$V_r \sin i$
1	25	−1·93	B 7	3·09	0·82	0·79	25
2	31	−1·63	B 6	3·08	0·63	0·79	300
3	48	−2·92	B 7	3·48	1·02	0·80	250
4	59	−2·16	B 8	3·22	0·95	0·83	150
5	60	−0·68	B 8	2·51	0·60	0·69	..

M_v and spectra are taken from Eggen's list, $V_r \sin i$—from Struve and Smith[2] *lg* L and *lg* R are calculated from M with the aid of Kuiper's temperature scale, *lg* M—is known from equations (3).

Now from equations (1–3) and taking into account that the absence of mixing leads to an increase of the ratio

$$\frac{\mu_{\text{core}}}{\mu_{\text{env.}}} = y$$

we work out the evolutionary paths back (see[8]) and find the initial values L_0, M_0, R_0. Sp_0 M_{v0} of these stars for that moment when they themselves were main sequence stars and their

$$\left(\frac{\mu_{\text{core}}}{\mu_{\text{env.}}} = y_0 = 1\right).$$

The results of our calculations are summarized in Table II.

The evolutionary paths are shown in Fig. 1 (arrowed curves). The initial points of these curves fall quite satisfactorily near the theoretical main sequence. A better coincidence could not be expected taking into account

TABLE II

N	$lg\ L_0$	$lg\ R_0$	$Lg\ M_0$	$(Sp)_0$	$(M_v)_0$	$\nu = \frac{\mu\ core}{\mu\ env}$	z
1	3·52	0·78	0·90	B 3	−2·3	1·6	10^7
2	3·51	0·59	0·90	B 2	−1·9	1·6	10^7
3	3·91	0·96	1·00	B 2	−3·2	1·7	10^7
4	3·66	0·90	0·94	B 3	−2·5	1·7	10^7
5	2·88	0·58	0·78	B 5	−1·0	1·4	10^7

the poor observational data of the stars in question and especially the uncertainties concerning bolometric corrections for early-type stars.

The results obtained suggest that the evolution of the hottest cluster stars proceeds in two ways. Mixed stars evolve along the main sequence. The stars in which no mixing is taking place " branch off " the main sequence to the right. In both cases the masses of the stars decrease during their evolution. The time interval required for the hottest unmixed star, η tau, to reach its presently observed position comes out to be about 10^7 years. The time interval required for a mixed star of the same luminosity to become the hottest cluster star, still observed now on the main sequence of the Pleiades cluster (star N 16 of Eggen's list: $M_v = 0·8$, Sp = B7) is also about 10^7 years. This time-interval 10^7 years may evidently be regarded as the lowest possible age of the Pleiades cluster in general.

E. Schatzmann[9] suggested that the hot early-type stars of the Pleiades are very young contracting stars without energy sources, having not yet reached the main sequence stage. Contracting and loosing mass by rotational instability these stars evolve towards the main sequence of the cluster. He estimates the time of this evolution to be about $3·8.10^6$ years.

Such an interpretation seems to us highly improbable in regard to the Pleiades cluster. According to Schatzmann a contracting star in becoming a main sequence star looses all its rotation. But the majority of the Pleiade stars of spectral types B and A, belonging to the main sequence, happen to possess quite appreciable rotational velocities. Schatzmann's suggestion leads, consequently, to a conclusion that the main bulk of the cluster star has

an origin, different from that of the part of its hottest stars, which form the upper end of the main sequence.

Our interpretation suggesting for all the cluster stars a common origin, but different trends of evolution, seems to meet with less difficulties.

References

1. Massevitch, A., 1951, *A. J., USSR.*, **28,** N 5.
2. Fessenkov, V., 1949, *ibid.*, **26,** N 2.
3. Massevitch, A., *ibid.*, 1949, **26,** N 4; 1951, **28,** N 1; *Les Prosessus Nucléaires dans les astres*. Louvain, 1954, p. 170.
4. Parenago, P., and Massevitch, A., 1951, *Publications of Sternberg Astr. Institute*, **20**.
5. Eggen, O., 1950, *A.P.J.*, **111,** 81.
6. Struve, O. and Smith, 1940, *Ibid.*, **100,** 360.
7. Struve, O., 1950, *Stellar Evolution*, Princeton.
8. Massevitch, A., 1953, *A. J., U.SSR.*, **30,** N 4.
9. Schatzmann, E., 1954, *Annales Astroph.*, **17,** 398.

EVOLUTIONARY TRENDS IN CLOSE BINARY SYSTEMS

By Zdeněk Kopal

(Department of Astronomy, University of Manchester)

Read at the Silver Jubilee Session of the Academy held at the University of Lucknow on December 28, 1955

The evolution of the stars is, in general, a process so slow when viewed in terms of our conventional time scales that no change due to this cause can, in general, be expected to unfold within the brief span of a few generations during which this subject has been studied.[1] All current theories of the evolutionary trends of *single* stars can, therefore, be tested only by confronting them with the observed *statistical* properties characterizing different types of stellar populations, and such comparisons are not necessarily unambiguous. Stars travelling singly through space are, on the whole, pretty reticent objects and their principal physical characteristics such as their masses or absolute dimensions—can likewise be inferred only by statistical methods. When we come, however, to consider *close binary systems* (*i.e.*, pairs of stars whose relative dimensions are comparable with their mutual separation), the situation alters at once and becomes much more favourable for the principal object of our inquiry. In embarking upon it we need not be deterred by a scarcity of the data: for close binary systems are by no means rare and occur among stars of all types—particularly among massive stars of early spectral classes among which evolutionary changes should be particularly conspicuous (on account of the rate at which such stars are expending their available hydrogen supply). A mutual symbiosis of two components of close binary systems is, moreover, conducive to revealing certain special features, of high evolutionary interest, which have only recently come to light.[2, 3, 4] As further possibilities latent in this field are still far from being exhausted, the aim of the present remarks will be to discuss them in more detail—not merely for the sake of a review of what has so recently been learned in this connection, but primarily in order to outline the trends which unfold when we pursue the present line of inquiry farther than has been done so far.

In order to do so, let us begin by recalling a few fundamental facts from the elementary theory of close binaries, and inquire as to the existence of a limiting size of the components in systems of given mass-ratio. Their free boundaries are known to be equilibrium surfaces over which the potential

of all forces acting on them remains constant. If (as we have every reason to expect) the density concentration of the components is so high that their gravitational potentials can be satisfactorily represented by those of central mass-point of masses $m_{1,2}$ separated by a distance R, the total potential W of combined forces acting on an arbitrary point P (x, y, z) of the surface can be expected as

$$W = G\left\{\frac{m_1}{r} + \frac{m_2}{r'}\right\} + \frac{w^2}{2}\left\{\left(x - \frac{m_1 R}{m_1 + m_2}\right)^2 + y^2\right\} \qquad (1)$$

where

$$r^2 = x^2 + y^2 + z^2,$$

$$r'^2 = (R - x)^2 + y^2 + z^2,$$

represent the distance of P from the centre of gravity of the two components, ω denotes the angular velocity of rotation of the system in the xy-plane, about the centre of gravity, and G stands for the constant of gravitation. The first term in curly brackets on the right-hand side of equation (1) represents the potential arising from the attraction of the two components, and the second stands for effects of centrifugal force.

Moreover, in close binary systems it is reasonable to identify ω^2 with the Keplerian angular velocity $G(m_1 + m_2)/R^3$, and in the case of contact systems this representation becomes inevitable. If we adopt it, the surfaces generated by setting W = constant on the left-hand side of the foregoing equation (1) are usually referred to as the *Roche Equipotentials*, and should closely approximate the forms of centrally-condensed components rotating with the Keplerian angular velocity irrespective of their proximity or mass-ratio. If W is large, the corresponding equipotentials (which coincide incidentally, with the surfaces of zero velocity of the restricted problem of three bodies) are known to consist of two separate ovals enclosing the centre of each one of the two bodies and differing but slightly from spheres. With diminishing value of W the ovals defined by (1) become increasingly elongated in the direction of the centre of gravity of the system—until, for a certain critical value of $W = W_0$ characteristic of each mass-ratio,[5] both ovals unite at a single point on the line joining the centres of the two stars (and coinciding with the inner Lagrangian point L_1 of the restricted problem of three bodies). This limiting surface—the largest *closed* equipotential capable of containing the whole mass of each component—will hereafter be referred to as their *Roche limit*. This limit is an intrinsic property of each system and depends only on its mass-ratio. The idea suggested itself recently to the writer of expressing the fractional dimensions, deducible from an analysis of light

curves of eclipsing systems with known mass-ratios, in terms of this limit,[6] and a discussion of the results has revealed that all systems possessing at least one (the more massive) component on the Main Sequence can be naturally divided into three groups of the following characteristics:

(1) *Detached Systems.*—The volumes of both components are significantly *smaller* than their Roche limits, but their fractional dimensions and mass-ratios are such as to render the values of W for both components sensibly *equal.* Both systems do not deviate significantly from the Main Sequence in the H.R.-diagram, and conform to statistical mass-luminosity and mass-radius relations. Their orbital periods are as a rule constant.

(2) *Semi-Detached Systems.*—The primary (more massive) components are significantly smaller than their Roche limits, but the *secondaries* appear to fill *exactly* (*i.e.*, within the limits of observational errors) the largest closed equipotentials capable of containing their whole mass. Such stars exhibit conspicuous subgiant characteristics, and deviate both from the Main Sequence and the mass-luminosity (or mass-radius) relation by having systematically too small a mass (or too large a radius) for their luminosity. Moreover, the orbital periods of systems possessing such components undergo often changes of abrupt nature.

(3) *Contact Systems.*—Both components appear to fill the respective loops of their Roche limits and are, therefore, probably in actual contact at the inner Lagrangian point L_1. Both stars lie (though not very closely) on the Main Sequence, but exhibit—whether individually or statistically—no vestige of any relation between mass and radius or luminosity. Abrupt period changes are frequent in systems of this type.

The systems of type (1) appear to be relatively most numerous among eclipsing binaries listed in existing catalogues of variable stars, though dwarf systems of group (3) (W UMa-type) may represent the most numerous binaries per unit volume of stellar population. The relative proportion of semi-detached binaries of group (2) is difficult to estimate on account of the role played by observational selection in their discovery, but in spite of their probable scarcity they represent a group whose existence is, in many respects, particularly thought-provoking. For what is the significance of the observed clustering of the sizes of the secondary components in systems of this type around their Roche limits? This fact is certainly not the result of a chance, for the probability of so peculiar a random distribution in fractional dimensions is negligibly small: among 64 Main-Sequence binaries, with known mass-ratios, which have been recently discussed by the writer,[6] not less than 11 are found to possess secondaries whose sizes coincide with those of their

Roche limits within the limits of observational errors. It indicates rather that these stars must have reached their limiting sizes by some kind of non-equilibrium processes. If the binary as a whole were contracting—for instance—from a single dumb-bell figure, there is no reason why any appreciable fraction of the secondaries should cluster around the Roche limit. If, on the other hand, such stars are secularly expanding, the reason for the observed clustering will be patent for no larger *closed* equipotential exists which would contain their whole mass. Therefore, *the growth in size of an expanding component of close binary systems is bound to be arrested at its Roche limit*, and the observed clustering of the secondary components of systems of our type (2) around this limit reveals that the tendency is latent in such stars as a group. The conclusion seems, therefore, inescapable that *subgiant components in close binary systems are secularly expanding*, and have been expanding in the course of their evolution for a long time.

Once the maximum distension permissible on dynamical grounds has been attained, a continuing tendency to expand is bound to bring about a secular loss of mass, streaming out of the conical end of the critical equipotential at L_1. The kinematic behaviour of matter ejected in this way constitutes an intriguing dynamical problem whose preliminary discussion was given by the writer elsewhere.[4] The object of my present remarks will be to raise another basic question arising in this connection: namely, *why only secondary (less massive) components, and not the primaries, exhibit a continuous tendency to expand*?

In order to appreciate this point, attention is invited to the accompanying Fig. 1 which exhibits a schematic view of two possible types of semi-detached systems (drawn to scale for a mass-ratio of 0·4). The diagram on the left (2 *a*) represents a type in which the secondary has attained the Roche limit (the primary being significantly smaller than its limit), while on the right one (2 *b*) the primary has expanded and the secondary remains smaller. Now we mentioned already that, out of 64 eclipsing binary systems with known mass-ratios, 11 (*i.e.*, 17%) turn out to belong to the type (2 *a*), not a *single* case of a binary of the type (2 *b*) has so far been found: their relative abundance (if any exist at all) appears, therefore, to be less than 2% in striking contrast to a known 17% population of group (2 *a*).

What is the reason underlying this curious disproportion? Before we attempt to follow up its possible evolutionary implications, let us forestall a question, in the reader's mind, concerning a possible role of observational selection in this matter. Can this disproportion be due (partly or wholly) to the fact that systems of the type (2 *a*) are more easily discovered than those

of the opposite type? In order to answer this question, let us single out some well-known detached eclipsing system—such as U Ophiuchi, for instance —and inquire as to the photometric consequences of expansion of its secondary

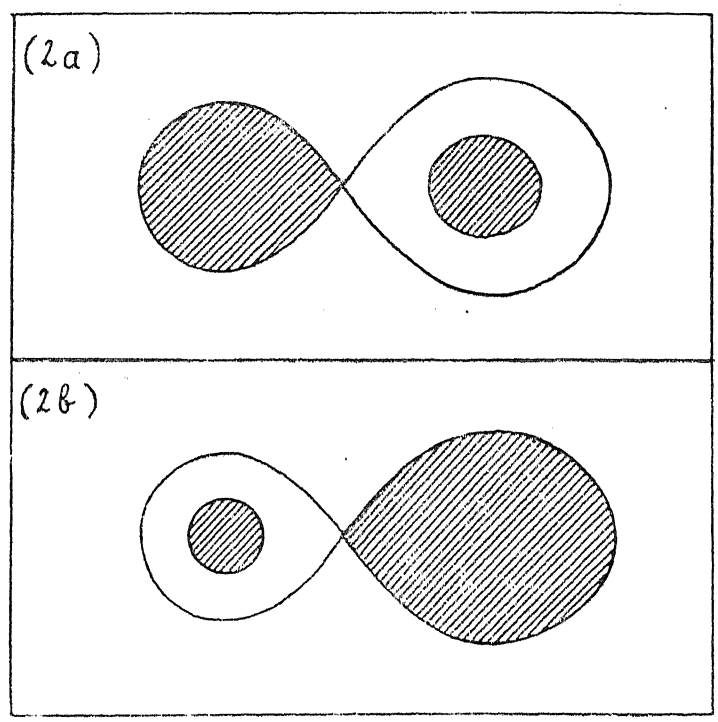


FIG. 1

component, and then of the primary, to their respective Roche limits. The results are diagrammatically shown in Fig. 2 confronting the geometry, and light curve, of the present system with those displayed if the system were secularly to expand into one of type (2 *a*) or (2 *b*), respectively. In its present state, the primary (more massive) component of U Ophiuchi is the larger of the two (their fractional dimensions being given by $r_1 = 0{\cdot}263 \pm 0{\cdot}002$ and $r_2 = 0{\cdot}247 \pm 0{\cdot}002$, respectively, according to Huffer and Kopal[7]), of greater surface brightness ($J_1/J_2 = 1{\cdot}12 \pm 0{\cdot}02$) as well as fractional luminosity ($L_1 = 0{\cdot}56 \pm 0{\cdot}01$), the primary (deeper) minimum is, therefore, due to a transit eclipse. If now the secondary component were to expand to its Roche limit, its radius (exposed to us at the time of the minima, for a mass-ratio $m_2/m_1 = 0{\cdot}88 \pm 0{\cdot}03$) would become $r_2 = 0{\cdot}364 \pm 0{\cdot}004$, and, if no mass were lost in the course of expansion and, therefore, the total luminosity of the star were to remain (approximately) the same, the surface

brightness of the secondary component would be lowered so that the ratio J_1/J_2 becomes equal to 2·43. Now the increased size of the secondary component would render the primary minimum an *occultation* which becomes *total* for 0·013 of a cycle, and its amplitude would increase from $0^m·68$ to $0^m·88$, whereas the reduced surface brightness of the secondary would diminish the amplitude of the secondary minimum (due to a transit culminating in an annular eclipse) from $0^m·56$ to $0^m·28$. The increased size of the secondary component would also widen the duration of the eclipses which would last 0·246 of a cycle, in contrast with their present duration of 0·169. In consequence, the light curve of a hypothetical eclipsing system obtained by converting U Ophiuchi into a semi-detached system of group (2 *a*) would be as shown on Fig. 2 alongside the geometrical model of the system.

If, as an alternative, we should expand the primary component without loss of mass to its Roche limit (type 2 *b*), its fractional radius becomes $r_1 = 0·386 \pm 0·004$, and (for constant luminosity) its surface brightness will be reduced 1·47 times so that $J_1/J_2 = 0·763$, rendering the secondary component the brighter (per unit area) of the two. In consequence, its eclipse by the primary component will give rise to the deeper minimum (of amplitude $0^m·83$) which becomes an occultation culminating in a total eclipse lasting 61 minutes, while the shallower minimum (of amplitude $0^m·49$) becomes an annular transit. The duration of the eclipses will then be 0·247 of a cycle and that of the total (annular) phase, 0·025—*i.e.*, even greater than in the preceding (2 *a*) case. The corresponding light curve is also shown in Fig. 2 alongside the geometrical model of the system.

A glance at the light curves plotted in Fig. 2 reveals that a secular expansion of the present system of U Ophiuchi into a semi-detached binary of the type (2 *a*) or (2 *b*) would bring about an increase in both the durations of the eclipses and the amplitudes of the deep minima, thus making the light variation of the system even more conspicuous. Hence, *observational selection favours the discovery of both types of semi-detached eclipsing systems*, and the 17% proportion of (2 *a*)-systems among known two-spectra binaries is undoubtedly exaggerated by such selection over their actual relative abundance. On the other hand—and this is essential—observational selection does *not* discriminate against discovery of semi-detached systems of our type (2 *b*) in contrast with those of the type (2 *a*)—if anything, the converse is true. The absence, among known binaries, of systems of the type (2 *b*) cannot, therefore, mean anything else than that such systems must be really very rare—if any exist at all—and their apparent absence confronts us with a problem which demands explanation.

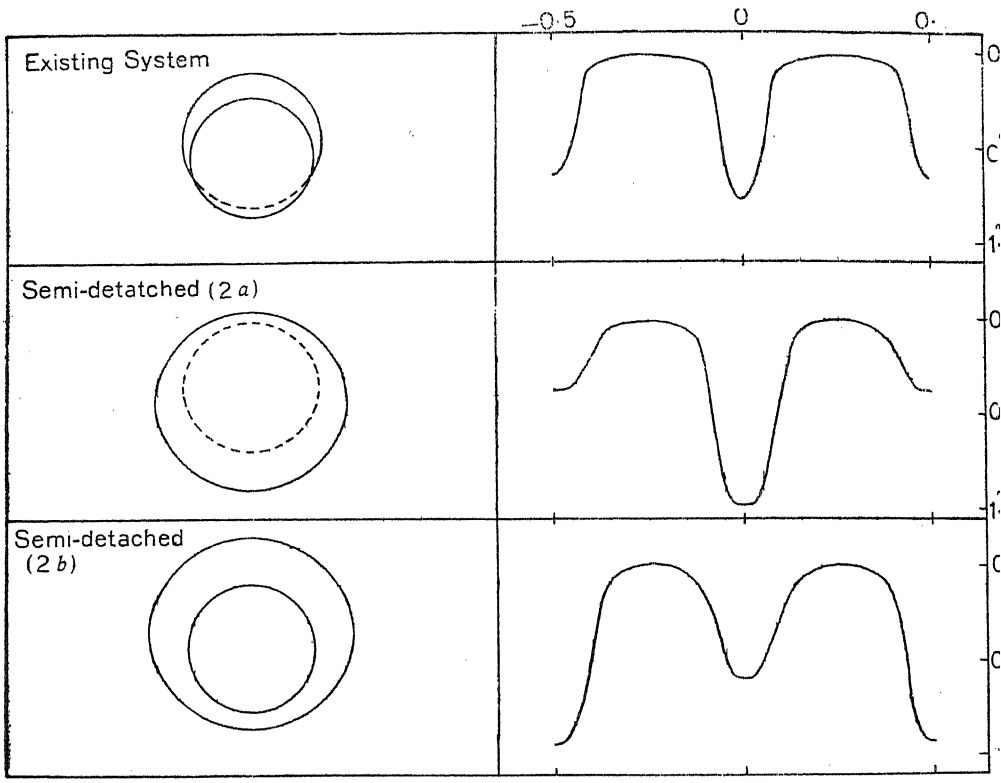


FIG. 2.

Top.—The geometry of the eclipsing system U Ophiuchi at the time of the primary minimum (left), and its observed light curve (*cf.* Huffer and Kopal, 1951, *Ap. J.*, **114**, 297) (right).

Centre.—The geometry of a hypothetical semi-detached eclipsing system, at the same phase, obtained by expanding the secondary component of U Ophiuchi to its Roche limit (left); and its corresponding theoretical light curve (right).

Bottom.—The geometry of a hypothetical semi-detached eclipsing system, at the same phase obtained by expanding the primary component of U Ophiuchi to its Roche limit (left); and its corresponding theoretical light curve (right). Note that, as a result of expansion, the primary component has now become one of lower surface brightness and, consequently, its eclipse will give rise to the shallower minimum.

This problem is all the more acute as our expectations of the existence of binaries of the type (2 *b*) were motivated not merely by reasons of symmetry, but by other considerations which are more difficult to set aside: and such considerations are intimately connected with the evolutionary trends of the individual components. There seems no room for doubt that the principal motive prompting the evolution of stars of the type with which we are concerned is a gradual depletion of their internal hydrogen content and its conversion into helium necessary to defray the energy balance of stellar radiation. Now it has been shown recently by several writers[8, 9]

that a hydrogen depletion in central regions is eventually bound to bring about a secular expansion of the stars as a whole. The rate of hydrogen conversion into helium is, moreover, empirically measured by their observed energy output per unit mass, and as this output is higher in the primary components than in the secondaries, the degree of hydrogen depletion in the central core, requisite for setting off secular expansion, should be attained in the primaries before the secondary reaches the same stage. If the observed expansion of subgiant components is due to this cause—and this is the likeliest surmise—it should, therefore, become operative in the primary, rather than the secondary, components of close binary systems in the first place. In other words, their primaries, not secondaries, should exhibit subgiant characteristics—whereas in actual fact we observe the converse to be true; namely, expanding secondaries appear to be fairly frequent, while expanding primaries are conspicuous by their absence.

In order to explain this fact, Crawford[3] advanced a hypothesis that the present subgiant secondaries are one-time primaries which have, after expansion to their Roche limits, lost enough mass to reverse the original balance of the mass-ratio. According to Crawford, each semi detached binary of our group (2) should begin its career as a member of the subgroup (2 *b*), and it is only a continuing tendency to expand (and the consequent secular loss of mass at L_1) which will eventually convert binaries of the type (2 *b*) into those of (2 *a*). This ingenious suggestion is, however, not supported by the available observational data: a complete lack of systems of the type (2 *b*), which no conceivable observational selection can explain, as well as of any semi-detached systems of mass-ratios in the neighbourhood of unity, vote against it. According to Crawford, a transition between systems of types (2 *b*) and (2 *a*) should be gradual and smooth—while, in reality, the hypothetical parent type (2 *b*) is conspicuous by its absence, and stars of the type (2 *a*) appear to form a rather compact group.* In all conspicuous cases on record, the expanding star at the Roche limit is very much less massive than its mate, and the simplest conclusion may seem that this has always been the case.

If, therefore, Crawford's attractive hypothesis is to be regretfully given up, two other possible explanations of the observed fact may merit exploring. The first is a possibility that in the early evolutionary stages—while both components of the systems still belonged to the Main Sequence—the

* An additional difficulty to Crawford's hypothesis arises from the existence of subgiant secondaries (such as RS CVn B, Z Her B, or AR Lac B, for instance) whose fractional dimensions are well inferior to those of their Roche limits.

secondary component managed to attain a higher temperature in its central regions than its more massive mate, and thus succeeded in consuming its hydrogen at a faster rate, even though the smaller over-all supply of protons did not allow it to attain the primary's luminosity: a subsequent expansion may be the consequence of this fact. An alternative explanation of the observed facts may concern the relative importance of mixing in stellar interiors. All investigations by Hoyle, Sandage and Schwarzschild[8, 9] referred to above proved expansion of hydrogen-poor stars on the assumption that mixing of the elements in central regions is ineffective, and that after exhaustion of hydrogen the star possesses an essentially isothermal pure helium core, surrounded by a hydrogen-rich envelope at a temperature too low for effective hydrogen burning, so that the actual energy production is limited to a narrow shell surrounding the core. It is true that, on this model, convection is incapable of coping with the developing difference in chemical composition of the core and of its envelope, and according to Sweet[10] or Mestel[11] axial rotation may likewise produce but negligible mixing. But is, in spite of the results of these investigations, the effective absence of mixing firmly established ? It should be emphasized that static models investigated so far involve several simplifying assumptions (neglect of radiation pressure, of relativistic degeneracy effects, absence of heavy elements, etc.) whose cumulative effects are rather difficult to assess, and above all, the mathematical convenience of splitting up the star into two discrete regimes, with abrupt change of several parameters at the interface, may introduce certain features into the model which have no counterpart in reality. At any rate, until much more work on such models has been done, it might be unwise to close our eyes before a possibility that the different dynamical behaviour of primary and secondary components in semi-detached binary systems may be a consequence of the different degree of mixing of the chemical elements in deep interior, that the growth of an isothermal helium core inside primary compoments may be prevented by effective mixing of the core with the envelope, while in absence of such mixing in the secondaries may be the cause of their secular expansion.

It should, however, be stressed that conjectures of this nature—even if well-founded—do not in any way solve the problem of the observed dynamical behaviour of components in close binary systems—but only relegate it to a different field of astrophysical theories. Is it, in particular, possible that less massive components of close pairs could develop at any time higher central temperatures (and thus attain higher rates of thermonuclear energy production) than their more massive mates ? Is it possible for internal mixing of matter to play so different a role in two components of the same pair ?

Above all: are these the right questions to ask in connection with the existence of semi-detached systems of a specific type? The answer is not yet known, but whatever may turn out to be its specific form, the significance of semi-detached binaries as proving ground for modern theories of stellar evolution can scarcely be any longer in doubt.

References

1. For a possible exception to this statement *cf.* STRUVE, O, 1955, *Publ. Astr. Soc. Pacific.* **67,** 29.
2. KOPAL, Z., 1954, *Mem. Soc. Roy. des Sci. de Liége,* **15,** 684.
3. CRAWFORD, J. A., 1955, *Astrophys. Journ.,* **121,** 71.
4. KOPAL, Z., *Proc., I.A.U. Symposium on Non-Stable Stars* (North Holland Publ. Co., Amsterdam, in press).
5. For their tabulation *cf.* KOPAL, Z., 1954, *A Study of the Roche Model, Jodrell Bank Annals,* **1,** 37.
6. KOPAL, Z. (Unpublished).
7. HUFFER, C. M. AND KOPAL, Z., 1951, *Astrophys. Journ.,* **114,** 297.
8. SANDAGE, A. R. AND SCHWARZSCHILD, M., 1952, *Ibid.,* **116,** 463.
9. HOYLE, F. AND SCHWARZSCHILD, M., 1955, *ibid.,* Suppl. No. 13, (**2,** 1).
10. SWEET, P. A., 1950, *Mon. Not. Roy. Astr. Soc.,* **110,** 548.
11. MESTEL, L., 1953, *ibid.,* **113,** 716.

ON THE EVOLUTIONARY CONNECTION BETWEEN STARS AND NEBULAE

By V. A. Ambartsumian

(*Bjurakan Astrophysical Observatory of the Academy of Sciences of the Armenian SSR*)

The question about the internal structure of the stars cannot be separated from the problems of stellar evolution. This is a consequence of the simple fact that individual stellar configurations, observed by us, must be considered as links of certain evolutionary sequences. The stores of energy, which supply stellar radiation, are determined by the initial state of the star at its origin. It is extremely important, therefore, for the theories of internal structure of the stars to know in what way and what kind of matter the stars originate from.

Traditional is the point of view that stars originate from diffuse matter, from nebulæ, in particular. This point of view has become so habitual that it seems rather audacious to suggest that there are no serious grounds supporting it. But meanwhile it is just the way matters are standing.

A study of stellar associations permitted us to pick out stars of a quite recent origin. Such *young stars* belong, in the main, to two types: (1) blue stars of high luminosity and (2) late type dwarfs with irregular changes of their luminosity (T Tauri type stars)—It is possible that there exist young stars of some other categories (there are some direct proofs in favour of it, but we shall discuss here the above-mentioned two types of stars).

It is rather essential that blue stars of high luminosity, usually met in groups in the space (0-associations and open clusters) are very frequently connected with diffuse nebulæ, sometimes very bright ones. For instance, among stellar clusters, containing 0-type stars, almost all of them are connected with diffuse nebulæ located in their vicinities.

The same is also the case in respect to associations of T Tauri type stars, connected with diffuse nebulæ (either with gaseous, or dust nebulæ). And at last, direct connection of individual T Tauri type stars with cometary nebulæ is quite evident.

The fact that all mentioned young stars are located in diffuse nebulæ, or in their vicinity, is, as it seems, a direct proof in favour of the origin of stars from diffuse matter,

If we add to the said above that the Herbig-Haro objects contained in the Orion association and apparently representing the earliest stage of evolution of the T Tauri type stars, are embedded in small nebulæ of irregular form, the connection between the origin of stars and the processes going on in the diffuse nebulæ becomes quite evident.

However, recent studies of the physics of the diffuse nebulæ have shown that these objects are unstable formations. They must rapidly disintegrate. The life-time of a diffuse nebula must be of the order of 10^6, and no more then 10^7 years. In this case it may, naturally, be suggested that diffuse nebulæ are but phenomena of short duration, accompanying the process of stellar formation. In other words, it may be admitted that stars and nebulæ are originating simultaneously, in groups, but the life-time of stars is large—of the order of 10^{10} years, while nebulæ dissipate rapidly. The older stars are therefore, as a rule, not connected with nebulæ.

Only one class of cosmic objects, in which the connection between a star and a nebula is of a simple and clear character, is known to us. These are the planetary nebulæ. The fact of the expansion of planetary nebulæ suggests that in this case the relation between the central star and the nebula is of such a kind that the nebula was ejected by the star. Thus, in this case, not the star has condensed from the nebula, but the nebula has originated from the star. There are, indeed, some facts in favour of the youth of the nuclei of planetary nebulæ. The suggestion about a simultaneous formation of the star and the nebula from some other matter is, therefore, not excluded, but it is out of question that the star has originated from the nebula. The age of the planetary nebulæ must be in this case of the order of 10^4 years.

Recent observations of the Herbig-Haro objects carried out by Herbig favour the suggestion that stars originate in them in the course of quite short intervals of time, literally in our sight. There are full grounds to suggest that nebulæ surrounding these stars are also very young, their age being of the order of 10^4–10^5 years.

It is interesting, however, that between the nebulæ in the Herbig-Haro's objects and the planetary nebulæ there is a similarity, namely that their diameters are of the same order (from 0·01 to 0, I parsec).

We see that though these two types of objects belong to totally different stellar populations, their extreme youth is in both cases connected with the rather small volume of the nebula.

The long age of the majority of stars, located for instance in O-associations (of the order of 10^6–10^7 years) corresponds to the presence of diffuse nebulæ of several ps. in diameter.

If, along with this, the fact of the expansion of individual diffuse nebulæ of peripheral form contained in stellar associations is taken into account, the following conclusion follows directly:—

To the earliest stages of stellar evolution correspond small volumes of nebulæ connected with such stars. Nebulæ of extremely large volumes correspond to later stages of stellar evolution.

Thus, the evolution does not proceed in the direction of a condensation of the nebulæ (in result of which the stars are originating), but in the direction of the expansion and dissipation of the nebulæ, which originated in the process of formation of stars and stellar groups.

There are no doubts, however, that the evolution of nebulæ is not restricted with their simple expansion. In so far as stars originate in groups, the nebulæ, the origin of which is connected with the origin of individual stars, may in the course of their expansion interact with one another. It is quite probable that the large diffuse nebulæ, like, for example, the Orion nebula, have originated in such a way.

It must also be taken into account that for a formation of a star as a radiating body from a prestellar matter, a certain interval of time is needed. Meanwhile the diffuse matter, which originated around the future star, may already begin to expand. In this case the radiation of the diffuse matter will start only at a certain stage, when this matter has already expanded to a certain volume and the star (or stars) had time enough to transform into a radiating body. Thus, in spite of the simultaneous origin of the star and the nebula, an impression may be created outwardly that a star originates in some already existing nebula and starts to illuminate it.

We did not pay attention to a most interesting question: what matter do the stars and nebulæ originate from? This most essential question of modern stellar cosmogony must be answered for the meantime rather indefinitely: the protostars must be *dense bodies* of yet unknown nature. They must not emit any appreciable radiation, at least in the visual spectral region.

Several years ago, when the hypothesis of the existence of dense protostars was suggested by us in order to explain the phenomena observed in stellar associations, it was met with scepticism by the majority of astronomers,

t must be admitted that the suggestions in favour of this hypothesis were rather uncertain at that time. Now we possess numerous data in favour of this hypothesis.

To-day, when we celebrate the Silver Jubileum of the Indian Academy of Sciences, we must admit that the astronomers of the great Indian people have made an essential contribution into the problem of investigation of the internal structure of the stars. Let us hope that the solution of the fundamental problems dealing with the origin of stars and nebulæ will be approached in the course of the nearest years.

272-58 Printed at the Bangalore Press, Bangalors City, by C. Vasudeva Rao, Superintendent.

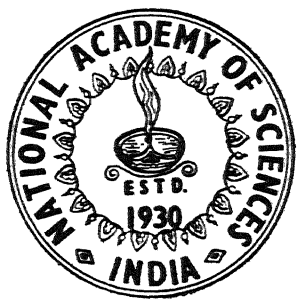
EDITORIAL BOARD

CONTENTS

THE NATIONAL ACADEMY OF SCIENCES, INDIA

ANNUAL NUMBER

1957



THE NATIONAL ACADEMY OF SCIENCES, INDIA

(Registered under Act XXI of 1860)

Founded 1930

Council for 1957

President

Prof. P.S. Gill, M.S., Ph.D., F.A.P.S., F.N.I., F.N.A.Sc., Aligarh

Vice-Presidents

Prof. N. R. Dhar, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Allahabad
Prof. W. D. West, M.A., C.I.E., Sc.D., F.A.S., F.N.I., F.N.A.Sc., Saugar

Honorary Treasurer

Prof. S. Ghosh, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Allahabad

Foreign Secretary

Dr. R. K. Saksena, D.Sc., F.N.I., F.N.A.Sc., Allahabad

General Secretaries

Dr. R. N. Tandon, M.Sc., Ph.D., D.I.C., F.N.A.Sc., Allahabad
Shri S. Basu, M.Sc., F.N.I., F.N.A.Sc., New Delhi

Members

Prof. P. L. Srivastava, M.A., D.Phil., F.N.I., F.N.A.Sc., Allahabad
Mrs. Savitri Sahni, M.Sc., F.N.A.Sc., Lucknow
Prof. S. Ranjan, M.Sc., D.Sc., F.N I., F.N.A.Sc., Allahabad
Prof. A. K. Bhattacharya, D.Sc., F.R.I.C., F.N.A.Sc., Saugar
Prof. K. Banerji, D.Sc., F.N.I., F.N.A.Sc., Allahabad
Prof. R. Misra, M.Sc., Ph.D., F.N.I., F.N.A.Sc., Banaras
Prof. M. D. L. Srivastava, D.Sc., F.N.A.Sc. Allahabad
Shri M. S. Randhawa, M.Sc., F.N.I., F.N.A.Sc., I.C.S., New Delhi
Prof. H. R. Mehra, M.Sc., Ph.D., F.N.I., F.N.A.Sc., Allahabad

---

The *Proceedings of the National Academy of Sciences, India,* is published in two sections: Section—A (Physical Sciences) and Section—B (Biological Sciences). Six parts of each section are published annually.

The Editorial Board in its work of examining papers received for publication is assisted, in an honorary capacity, by a large number of distinguished scientists. Papers are accepted from members of the Academy *in good standing.* In case of a joint paper, one of the authors must be a member of the Academy. The Academy assumes no responsibility for the statements and opinions advanced by the authors. The papers must conform strictly to the rules for publication of papers in the *Proceedings.* A total of 50 reprints are supplied free of cost to the author or authors. The authors may have any reasonable number of additional reprints at cost price, provided they give prior intimation while returning the proof.

Communications regarding contributions for publication in the *Proceedings,* books for review, subscriptions etc., should be sent to the General Secretary. The National Academy of Sciences, India, Lajpatrai Road, Allahabad-2 (India).

Annual Subscription for each Section : Rs. 30 (Inland); 60 sh. (Foreign)
Single Copy : Rs. 5 (Inland) : 10 sh. (Foreign).

THE

NATIONAL ACADEMY OF SCIENCES, INDIA

ANNUAL NUMBER

1957

THE TWENTY—SEVENTH ANNUAL SESSION

By

S. P. MITRA, M.Sc., D.Phil., F.N.A.Sc.

Officer-on-Special Duty, National Academy of Sciences, India

The twenty-seventh annual session of the National Academy of Sciences, India was held at the Mahakoshal Mahavidyalaya, Jabalpur at the invitation of the infant University of Jabalpur from 26th to 28th December 1957. This was the second time that an annual session of the Academy was held in Madhya Pradesh and due to the fact that this session of the Academy was the first major conference invited by the University of Jabalpur, it evoked keen enthusiasm among the Scientists of the State, particularly those at the University of Jabalpur.

The Session opened with the reading of messages by Dr. R. N. Tandon, General Secretary of the Academy. Pandit Kunjilal Dubey, Vice-Chancellor of the University of Jabalpur and the Chairman of the Reception Committee extended a hearty welcome to the delegates. After tracing the history of modern education at Jabalpur, he dealt with the role of scientists in the progress of the nation.

The General Secretary then presented the Secretaries' Report for 1957 reporting the progress of the Academy and announced the office bearers for 1958. He also announced the award of the Uttar Pradesh Government Education Minister's Gold Medal for 1957 for the best research papers published in Zoology in the Proceedings of the Academy from 1952 to 1957 to Dr. S. M. Das, Assistant Professor of Zoology, University of Lucknow and the election of Prof. G. Herzberg, Director, Division of Physics, National Research Council of Canada as an Honorary Fellow of the Academy.

Prof. P. S. Gill in his Presidential Address discussed the problem of the training of Scientists and stressed the role that this Academy can play in furthering Scientific research in cooperation with the Universities. He also described the new particles of Physics.

Dr. Kailash Nath Katju, Chief Minister of Madhya Pradesh in his Inaugural Address dealt with the role that this Academy can play in the progress of India.

Prof. A. K. Bhattacharya in his Presidential Address to the Physical Sciences Section discussed the problem of chemical reactivity and light absorption. 53 papers were presented at the meetings of this Section. Prof. R. Misra, in his Presidential address to the Biological Sciences Section described his work on plant ecological studies in Madhya Pradesh. 44 papers were read and discussed at the meetings of this Section. Prof. N. R. Dhar in his Presidential Address to the Symposium on Photochemical Reactions including Photosynthesis discussed the importance of photo-chemical reactions. 8 papers were read and discussed at this symposium.

Popular lectures were delivered by (1) Prof. N. R. Dhar, Director, Sheila Dhar Institute of Soil Science, University of Allahabad (2) Prof. P. S. Gill, Head of the Department of Physics, Aligarh Muslim University (3) Dr. M. S. Mani, Deputy Director, Zoological Survey of India (4) Prof. W. D. West, Head of the Department of Geology, University of Saugar and (5) Dr. D. Sharma, Assistant Professor of Physics, University of Allahabad.

77 delegates from all over the country attended the session which was an unqualified success. Excellent arrangements were made by the Reception Committee and nothing better could have been done. Excursions were arranged to Water Works, Pariat Tank, Burn & Co., Technical and Development Centre of the Post and Telegraph Department, Engineering College, Marble Rocks and Water Fall. An English drama, a Hindi drama and musical programme was arranged for the delegates and the Reception Committee printed a beautiful Souvenir volume containing the history and development of Jabalpur.

The grateful thanks of the Academy are due to every member of the Reception Committee for the admirable arrangements made, particularly to the two Local Secretaries Dr. M. S. Rao, who literally spent many sleepless nights and Shri C. S. Raghavan who was omnipresent to look after the arrangements. Sincere thanks of the Academy are due to Shri U. Misra without whose sympathy, consideration and interest, it would not have been possible to hold the Session at Jabalpur, Dr. R. L. Nirula who bore the main burden and Dr. S. C. Pandeya, who inspite of poor health moved like a shuttlecock and spent three nights on the railway platform. Best thanks of the Academy are due to the Principal of the Engineering College for the "At Home" and Messers. Vijayam Brothers for the "Dinner."

TWENTY-SEVENTH ANNUAL SESSION OF THE NATIONAL ACADEMY OF SCIENCES, INDIA, ALLAHABAD

PROGRAMME

Thursday, 26th. December, 1957

2-30 p.m. Annual Meeting at the Hall of Mahakoshal Mahavidyalaya, Jabalpur (M. P.)

1. National Anthem.
2. Appointment of two Scrutineers by the President to count votes.
3. Reading of Messages by Dr. R. N. Tandon, M.Sc , Ph.D., D I.C., F.N.A.Sc., General Secretary of the Academy.
4. Welcome Address by Pt. Kunjilal Dubey, Vice-Chancellor, University of Jabalpur and Chairman of the Reception Committee.
5. Annual Report by Dr. R. N. Tandon, M.Sc., Ph.D., D.I.C., F.N.A.Sc., General Secretary of the Academy
6. Address by Prof. P S. Gill, M.S., Ph.D., F.N.I., F.N.A.Sc., President of the Academy.
7. Inaugural Address by Dr. Kailash Nath Katju, Chief Minister of Madhya Pradesh.
8. Presentation of Uttar Pradesh Government Education Minister's Gold Medal for 1957 for the best papers published in the Proceedings of the Academy in Zoology.
9. Announcement of Office Bearers for 1958 by Dr. R. N. Tandon, M.Sc., Ph.D., D.I.C., F.N.A.Sc., General Secretary of the Academy.
10. Vote of thanks to Dr. Kailash Nath Katju, Chief Minister of Madhya Pradesh.
11. Vote of thanks to the University of Jabalpur.
12. Photograph of Members, Delegates and Distinguished Guests.
13. Opening of Scientific Exhibition by Dr. K. N. Katju.

5 to 6 p.m. 'At Home' by the Local Reception Cemmittee.

6 to 7 p.m. Popular Lecture by Prof. N. R. Dhar, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Director, Sheila Dhar Institute of Soil Science, University of Allahabad on 'Progress of Science.'

7 to 8 p.m. Popular Lecture by Prof. P. S. Gill, M.S., Ph.D., F.N.I., F.N.A.Sc., Head of the Department of Physics, Aligarh Muslim University on "Sputnik."

8 to 9 p.m. Dinner Interval.

9 to 10 p.m. Entertainment.

Friday, 27th December, 1957

8 to 9-30 a.m. Excursions to Water Works and Pariat Tank.

10 a.m. to 1 p.m. Sectional Meetings:—

Physical Sciences Section under the Presidentship of Prof. A. K. Bhattacharya, D. Sc., F.R.I.C., F.N.A. Sc., Head of the

	Department of Chemistry, University of Saugar in the Physics Lecture Theatre (First Floor) of Mahakoshal Mahavidyalaya.
	Biological Sciences Section under the Presidentship of Prof. R. Misra, M.Sc., Ph.D., F.N.I., F.N.A. Sc., Head of the Department of Botany, Banaras Hindu University in the Physics Lecture Theatre (Ground Floor) of Mahakoshal Mahavidyalaya.
1 to 2 p.m.	Lunch Interval.
2 to 4 p.m.	Symposium on 'Photochemical Reactions including Photosynthesis in Plants' under the Presidentship of Prof. N. R. Dhar, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Director, Sheila Dhar Institute of Soil Science, University of Allahabad in Physics Lecture Theatre (First Floor) of Mahakoshal Mahavidyalaya.
4 to 5 p.m.	Visit to Engineering College.
5 to 6 p.m.	'At Home' by the Principal, Government Engineering College, Jabalpur.
6 to 7 p.m.	Popular Lecture by Dr. M. S. Mani, Deputy Director, Zoological Survey of India on 'A Scientist on the Throne of Gods'.
7 to 8 p.m.	Popular Lecture by Prof. W. D. West, M.A , C.I.E , D.Sc., F.A.S., F.N.I, F.N.A.Sc., Head of the Department of Applied Geology, University of Saugar on 'The Origin of Scenery around Saugar.'
8 to 9 p.m.	Dinner by the Local Reception Committee.
9 to 10 p.m.	Entertainment.

Saturday, 28th December, 1957

8-30 to 10 a.m.	Excursion to Burn & Co., and P. & T. Technical and Development Centre.
10 to 11 a.m.	Popular Lecture by Dr. D. Sharma, M.Sc., D.Phil., F.N.A.Sc., Assistant Professor of Physics, University of Allahabad on "Travel in Space."
11 a.m. to 1 p.m.	Sectional Meetings.
1 to 2 p.m.	Lunch Interval.
2 to 5-30 p.m.	Excursion to "Marble Rocks and Water Fall" and "At Home" at "Marble Rocks."
5-30 to 8 p.m.	Sectional Meetings.

Messages

1. Dr. S. Radhakrishnan, Vice-President of India :

I am glad to know that the National Academy of Sciences is having its Twenty-seventh annual session at Jabalpur on the 26th and 27th December 1957. Insofar as science and technology are concerned, we have still a long way to go. If your annual session can help to accelerate our scientific progress, it shall have done a good thing.

2. Governor's Secretary, Uttar Pradesh :

The Governor is very happy to learn about the XXVII Annual Session of the National Academy of Sciences, India, which is being held at Jabalpur on the 26th and 27th December 1957. He sends his best wishes for the success of the Conference.

3. Prof. M. S. Thacker, President, Indian Science Congress Association :

We are pleased to learn that the National Academy of Sciences, India will be holding its 27th Annual Session at Mahakoshal Mahavidyalaya, Jabalpur, on the 26th and 27th December, 1957. With the immense role of Science in the promotion of human welfare and material prosperity and the important place assigned to it in the development plans of our country, the function of an organization like your Academy have increased tremandously and I have every hope that the Academy will very successfully discharge its functions and responsibilities that lie ahead of it.

On behalf of the Indian Science Congress Association I wish to convey our sincere good wishes for a very successful and eventful Session.

4. Prof. P. C. Mahalanobis, President, National Institute of Sciences of India :

We shall have to overcome many difficulties in promoting national development. We shall be able to do this only if Scientists and technologists take their own responsibilities seriously. Conference of Scientists can make very significant contributions in this regard. On behalf of my colleagues in the N. I. S. I., I send our best wishes for the Twenty-seventh Annual Session of the National Academy of Sciences, India.

5. Dr. D. N. Wadia, Geological Adviser, Department of Atomic Energy, Government of India :

As an old Member of the Academy, it gives me great pleasure at its holding its 27th Annual Session. This Academy fills an important place in the Scientific life of the community and I hope as it crosses annually the mile-stones, it gathers strength and vitality for greater and greater service to the Scientists of the country.

6. Registrar, University of Poona :

The University wishes the Conference every success.

7. Sri C. N. Chak, Director of Education, Uttar Pradesh :

Wishes the function all success.

ADDRESS BY THE CHAIRMAN OF THE RECEPTION COMMITTEE

By

PANDIT KUNJILAL DUBEY,

Vice-Chancellor, University of Jabalpur

DR. KATJU, DR. GILL, MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES, INDIA, LADIES AND GENTLEMEN:

On behalf of the University of Jabalpur and the Local Reception Committee, I offer the warmest welcome to the members of the National Academy of Sciences, India, who have honoured the University of Jabalpur by responding to its invitation and assembled here in conference in this year of the birth of the University.

As a University, Jabalpur is an infant. In literature and tradition, Tripuri has been famous as a seat of learning. But even as a centre of modern University education, Jabalpur is fairly old—one of its colleges having celebrated its centenary 20 years ago. By gradual development, we have now reached a stage when we are providing undergraduate and post-graduate courses in seventeen colleges, all located in the City of Jabalpur, and in ten Faculties—symbolised by the ten petals of the central lotus in our Coat of Arms—which include the Faculties of Science, Home Science, Veterinary Science, Medicine and Engineering. Within a couple of years, our College of Engineering with its Honours and Post-graduate courses bids fair to be the largest College of Engineering in India. We are also making a modest endeavour in the direction of research and hope that this session of the Academy of Sciences will invigorate our efforts in the direction.

In the history of India, the Narmada has been the dividing line between the North and the South. But Jabalpur is—geographically speaking—the centre of India and we are confident that meetings of the distinguished men of science and culture who have assembled here—and, I hope, will assemble in future—will gradually convert the Narmada into a unifying line of India, so that Jabalpur can develop into a centre of India in a truly scientific sense. The idea of our national planners to join the Ganga and the Godavari through the medium of the Narmada is an auspicious augury for the fulfilment of this aspiration of Jabalpur.

The opening sessions of conferences of scientists often provide an occasion for laymen to indulge, with some impunity, in talks *about* science, if not *of* science. It is necessary to resist this temptation in an age of specialization in which men of science are—almost in vengeance against the astrological control of men by planets,—seeking to establish control of planets by men. A layman should, in any case, fear to —tread the territory of scientists for, in respect of their basic data and principles, scientists of a particular period seem to present a united front before the rest of the community—unlike philosophers, who delight in seeking agreement with their ancestors rather than with their contemporaries. But men of science are, after all, men and laymen should, therefore, be sometimes given freedom to talk to them as man-to-man.

In the nineteenth century, Herbert Spencer had claimed that the progress of civilization of a country is indicated by the quantity of soap it consumes. We have progressed since and today we might say that the character of a modern nation is largely indicated by the amount it spends on education and research in science and, even more, by the direction in which its science and technology move. We are a peaceful nation and so our national planning for science and technology has been directed towards cultivating arts of peace rather than creating engines of destruction. While, in a very true sense, all science and technology are international, the tempo and direction of their progress are largely determined by the needs of the nation in which they take root and from which they derive their sustenance. The thinkers of India had, in fact, classified their sciences, not according to their special subject-matters, but according to the human goals they were intended to achieve — Dharma, Artha, Kama and Moksha. We may, therefore, well ask ourselves whether, while moving into new horizons, we are paying sufficient attention to such problems as those of the horizons of our soil and its nutrition. I am glad that such problems are engaging the attention of some of the distinguished members of this Academy and, what is more, their work is receiving recognition overseas. Agriculture of India is almost a part of the culture of India. Our ancient scriptures laid down that food makes the man and scientists like Marett have advanced the theory that composition of the food is largely responsible for the origin of races. In the present context of the economic progress of India, it needs much more scientific attention than it has been possible to give it so far. So too minerals below the soil which constitute the hidden wealth of India, waiting to be drawn up by those who may have the skill and strength and vision to do so.

Specialization is almost the soul of modern science and technology. Day to day we are learning more and more, — about less and less. This has its high advantages but it has its severe disadvantages too. So far as the Universities of India are concerned, specialized institutions of science affect them in more than one way. Specialized laboratories and institutes of science and technology have deprived the Universities of the services of a number of distinguished men of science who enriched the University life in recent decades. Most of these men had received their training and education as teachers in Universities and in many cases it is difficult to replace them. This is not merely a loss to University education. At least to some extent it has deprived these distinguished men of the great stimulus that springs from the combination of teaching with research. The instruction and research in specialized institutions cannot take the place of the education and research in a University, where they are conducted in an atmosphere surcharged with the ideas and beauties and fruitfulness created by the inter-action of the various Faculties on the minds of its members, senior and junior. Specialised institutions help us in securing a better standard of living, but life is more than living. The narrowness of specialization may even affect the mental attitude and approach of scientists themselves and obstruct their efforts to rise to a synoptic vision of the world as a whole. I am glad that this Academy, composed as it is largely of University men, runs no such risks in its scientific endeavours.

I hope that this old college of Arts and Science—which has been sufficiently progressive to have changed both its name and habitation at least four times in its history — will provide a congenial atmosphere for your deliberations of three days. We have made an endeavour to make your stay comfortable, but we have our severe limitations. We lack the amentities of large cities and the physical paraphernalia and towering personalities of the older and larger Universities. There must also have been several omissions and shortcomings in our arrangements

for your hospitality. I am confident that, in the largeness of your heart, you will forgive them all.

We are fortunate in having today in our midst our Chief Minister, Dr. Kailash Nath Katju, a good friend of all good causes, to bless us and to preside at the opening session of this Academy. We offer him a warm welcome on this occasion. The presence of a leader of his deep wisdom, characteristic Indian approach to current problems and great experience of public life, augurs well for the success of this session and, I am sure, it will inspire us all, both in our deliberations and in the execution of our respective tasks.

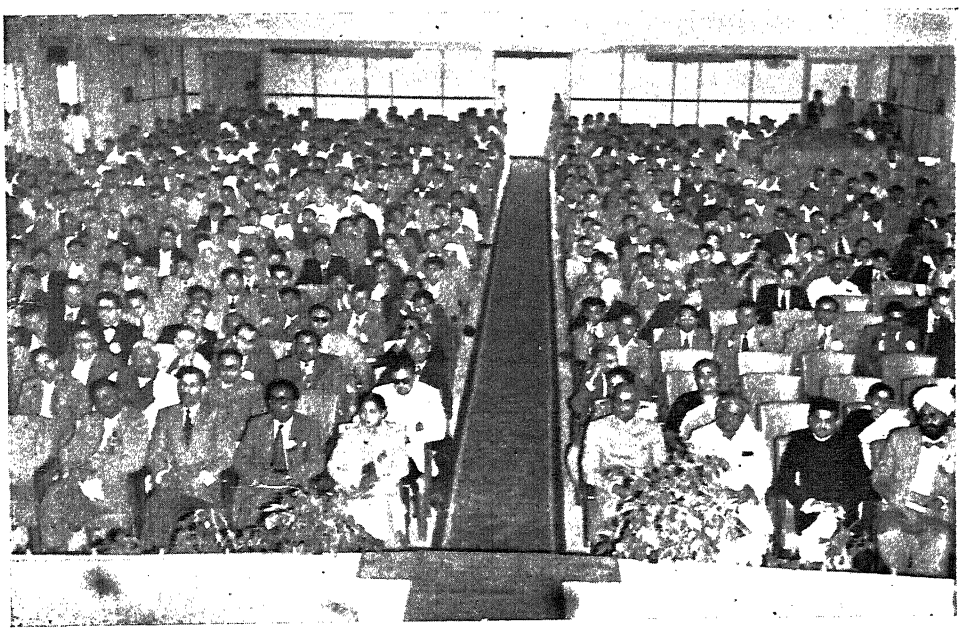
I now invite the officers and members of the Academy to proceed with the proceedings of this opening day of the 27th Session of the National Academy of Sciences, India.

Twenty-Seventh Annual Session

AT

University of Jabalpur

26th to 28th December, 1957



General view of the audience at the opening session.

Twenty-Seventh Annual Session

AT

University of Jabalpur

26th to 28th December, 1957

Dr. S. M. Das receiving the U. P. Government Education Minister's Gold Medal for 1957 from Dr. K. N. Katju.

SECRETARIES' REPORT

Presented at the 27th Annual Session of the National Academy of Sciences, India, held from 26th to 28th December 1957 at the Hall of Mahakoshal Mahavidyalaya, Jabalpur

By Dr. R. N. TANDON, M.Sc., PH.D. (London), D.I.C., F.N.A.Sc.

We have the pleasure to submit the following report on the working of the National Academy of Sciences, India, during the period 1st January to 31st December 1957.

OBITUARIES

During this period the Academy has sustained great loss due to the sad demise of the following distinguished fellows and well wishers of the Academy:—

1. Pt. Ravi Shanker Shukla, Chief Minister, Madhya Pradesh.
2. Dr. S. K. Pramanik, Deputy Director-General of Observatories, Indian Meteorological Department.

MEMBERS

The Academy has now on its rolls 266 members of whom 120 are fellows.

ORDINARY MEMBERS

The following new members have been elected during the year under review and we take this opportunity to welcome them:—

1. Dr. B. P. Srivastava, Department of Agriculture, College of Agriculture, Udaipur (Rajasthan).
2. Dr. S. P. Srivastava, Assistant Professor of Chemistry, D.S.B. Govt. Degree College, Naini Tal (U. P.)
3. Dr. M. P. Singh, Assistant Professor of Chemistry, University of Allahabad (U.P.)
4. Dr. M. A. Beg, Lecturer in Chemistry, Aligarh Muslim University, Aligarh (U.P.)
5. Dr. Aryabhusan Gupta, Associate Professor of Botany, D. A. V. College, Kanpur (U. P.)
6. Shri Prakash Narain Agarwal, Lecturer in Zoology, D. A. V. College, Kanpur (U.P.)
7. Shri K. P. Srivastava, Department of Zoology, University of Lucknow, Lucknow (U. P.)
8. Dr. Sanjib Chandra Baugh, Assistant Professor of Zoology, University of Lucknow, Lucknow (U. P.)
9. Dr. Onkar Nath Srivastava, Professor of Zoology, K. N. Govt. Degree College, Gyanpur, Varanashi (U.P.)
10. Shri S. C. Chakravarti, Professor and Head of the Department of Botany, Govt. Hamidia College, Bhopal (M.P.)

11. Shri Jagat Narain Saksena, Lecturer in Zoology, Govt. Science College, Raipur (M. P.)

12. Dr. M. L. Dhar, Assistant Director, Central Drug Research Institute, Lucknow (U.P.)

13. Shri Bijay Singh Chandel, Assistant Professor of Zoology, B. R. College, Agra (U.P.)

14. Shri Ganga Prasad Agarwal, Lecturer in Botany, Department of Botany, Mohakoshal Mahavidyalaya, Jabalpur (M. P.)

15. Dr. Krishna Sahai Bilgrami, Botany Department, University of Allahabad, Allahabad (U. P.)

16. Dr. G. S. Puri, Regional Botanist, Western Circle, Botanical Survey of India, Poona (Bombay)

17. Dr. Niranjan Das, Assistant Professor of Botany, University of Allahabad, Allahabad (U. P.)

18. Dr. Suresh Chandra Srivastava, Assistant Professor of Zoology, Lucknow University, Lucknow (U. P.)

19. Dr. Amar Singh, Assistant Professor of Botany, University of Allahabad, Allahabad (U. P.)

20. Dr. J. B. Lal, Industrial Chemist to U. P. Govt., Harcourt Butler Technological Institute, Kanpur (U. P.)

21. Dr. B. R. Puri, Reader in Physical Chemistry, Punjab University, Hoshiarpur (Punjab)

22. Dr. R. S. Choudhuri, Reader-in-Agricultural Botany and Physiologist, College of Agriculture, Banaras Hindu University, Varanasi (U. P.)

23. Shri G. Sitaramaiah, Assistant Professor of Chemistry, Birla College, Pilani (Rajasthan)

24. Dr. Rama Shanker Rai, Research Scholar, Department of Chemistry, University of Allahabad, Allahabad (U. P.)

25. Dr. Sheo Gopal Misra, Assistant Professor of Chemistry, University of Allahabad, Allahabad (U. P.)

26. Dr. R. L. Gulati, Lecturer in Mathematical Statistics, Department of Mathematics, Delhi University, Delhi.

27. Shri V. Lakshmikanth, Lecturer in Mathematics, Osmania University, Hyderabad (Deccan).

28. Shri S. M. Kar, Officer-on-Special Duty (Text Books), U. P., Lucknow.

29. Dr. S. P. Tandon, Assistant Professor of Chemistry, University of Allahabad, Allahabad (U. P.)

30. Dr. Bisheshwar Dayal, Reader in Physics, Banaras Hindu University, Varanasi (U. P.)

31. Shri V. V. L. N. Rao, Department of Mathematics, Banaras Hindu University, Varanasi (U. P.)

FELLOWS

We have great pleasure in announcing the election of the following new Fellows of the Academy for the year 1957.

1. Dr. R. S. Choudhri, Reader-in-Agricultural Botany and Physiologist, College of Agriculture, Banaras Hindu University, Varanasi (U.P.)
2. Dr. Moti Lal Dhar, Assistant Director, Central Drug Research Institute, Lucknow (U.P.)
3. Dr. R. N. Lakhanpal, Reader, Birbal Sahni Institute of Palaeobotany, Lucknow.
4. Dr. Amar Singh, Assistant Professor of Botany, University of Allahabad, Allahabad (U.P.)
5. Dr. S. N. Prasad, Assistant Professor of Zoology, University of Allahabad, Allahabad (U.P.)
6. Dr. S. P. Raychoudhuri, Head of the Division of Agricultural Chemistry and Soil Science, Indian Agricultural Research Institute, New Delhi.
7. Dr. S. C. Ghosh, Assistant Professor of Zoology, University of Allahabad, Allahabad (U.P.)
8. Dr. S. M. Das, Assistant Professor of Zoology, University of Lucknow, Lucknow (U.P.)
9. Dr. Hrishi Bhu Tewari, Assistant Professor of Zoology, University of Lucknow, Lucknow (U.P.)

HONORARY FELLOWS

We have great pleasure in announcing the election of Professor G. Herzberg, Director, Division of Physics, National Research Council of Canada as an Honorary Fellow of the Academy.

MEETINGS

During the year under report 8 meetings of the Council, 6 Ordinary Meetings (including annual meeting) and 3 meetings of the Fellows were held. It has also been decided that Ordinary Meetings will now be held on the 1st Friday of every month. In case that day happens to be a holiday, the meetings should be held on the next working Friday. This rule makes it possible for the members and Fellows to plan their programme well in advance and it permits a larger number of ordinary meetings where papers can be read and discussed.

ANNUAL SESSION

The 26th Annual Session was held at the Aligarh Muslim University on the 3rd and 4th February 1957. Dr. C. D. Deshmukh, Chairman, University Grants Commission presided over the meeting. About 80 delegates from different parts of the Country attended the session. The Academy received messages of goodwill from many scientists and leading Academic bodies of India.

Physical Sciences Section was presided over by Professor D. S. Kothari, Head of the Department of Physics, University of Delhi, Delhi and 60 papers were read and discussed at the meeting of this section.

The Biological Sciences Section was presided over by Dr. M. S. Mani, Deputy Director, Zoological Survey of India and 30 papers were read and discussed at the meeting of this section.

A Symposium on "Molecular Spectra and Molecular Structure" was held under the Presidentship of Prof. P.S. Gill, Head of the Physics Department, Muslim University, Aligarh.

The following popular lectures were delivered and they were largely attended.

1. "World Food Situation and its improvement" by Prof. N. R. Dhar on the 3rd February 1957.
2. "Molecular Spectra" by Prof. G. Herzberg, Director, Division of Physics, National Research Council of Canada on 3rd February 1957.
3. "Atomic Radiations and its hazards" by Prof. D. S. Kothari on the 4th February 1957.

The Uttar Pradesh Government Education Minister's Gold Medal for the best research work published in the Proceedings of the Academy for 1956 was awarded to Dr. C. L. Dhawan, Physical Chemist, Irrigation and Power Research Institute, Amritsar for his papers on Agriculture published in the Proceedings of the Academy (1951-1956).

The Academy is thankful to Col. B. H. Zaidi, Vice-Chancellor of the Muslim University, Aligarh and the Chairman of the Reception Committee, the Local Secretaries Prof. M. O. Farooq and Dr. S. M. Ali and the staff of the Muslim University, Aligarh for the excellent arrangements made for the success of the session.

COUNCIL

The following office bearers were elected for the year 1957.

PRESIDENT

1. Prof. P. S. Gill, M.S., Ph.D., F.A.P.S., F.N.I., F.N.A.Sc., Aligarh.

VICE-PRESIDENTS

2. Prof. N. R. Dhar, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Allahabad.
3. Prof. W. D. West, M.A., C.I.E., Sc.D., F.A.S., F.N.I., F.N.A.Sc. Saugar.

HONORARY TREASURER

4. Prof. S. Ghosh, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Allahabad.

FOREIGN SECRETARY

5. Dr. R. K. Saksena, D.Sc., F.N.I., F.N.A.Sc., Allahabad.

GENERAL SECRETARIES

6. Dr. R. N. Tandon, M.Sc., Ph.D., D.I.C., F.N.A.Sc., Allahabad.
7. Sri S. Basu, M.Sc., F.N.I., F.N.A.Sc., New Delhi.

MEMBERS

8. Prof. P. L. Srivastava M A., D.Phil., F.N.I., F.N.A.Sc., Allahabad.
9. Mrs. Savitri Sahni, M.Sc., F.N.A.Sc., Lucknow.
10. Prof. S. Ranjan, M.Sc., D.Sc., F.N.I., F.N.A.Sc., Allahabad.
11. Prof. A. K. Bhattacharya, D.Sc., F.R.I.C., F.N.A.Sc., Saugar.
12. Prof. K. Banerjee, D.Sc., F.N.I., F.N.A.Sc., Allahabad.
13. Prof. R. Misra, M.Sc., Ph.D., F.N.I., F.N.A.Sc., Varanasi.
14. Prof. M. D. L. Srivastava, D.Sc., F.N.A.Sc., Allahabad.
15. Shri M. S. Randhawa, M.Sc., F.N.A.Sc., F.N.I., I.C.S., New Delhi.
16. Prof. H. R. Mehra, M.Sc., Ph.D., F.N .I., F.N.A.Sc., Allahabad.

The following fellows of the Academy served on the council of the National Institute of Sciences of India, during 1957.

ADDITIONAL VICE-PRESIDENT

1. Prof. P. S. Gill, M.S., Ph.D., F.A.P.S., F.N.I., F.N.A.Sc., Aligarh.

ADDITIONAL MEMBER

1. Prof. P. L. Srivastava, M.A., D.Phil., F.N.I., F.N.A.Sc., Allahabad.

Prof. N. R. Dhar, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Allahabad, served on the Indian National Commission for Co-operation with UNESCO during 1957.

DISTINGUISHED VISITORS

During the year under report the following distinguished scientists and educationists visited the Acadamy :

1. Prof. R. E. Grim, Research Professor of Geology, University of Illinois, Urbana, Illinois, U. S. A. on the 13th February, 1957.
2. Prof. S. N. Bose, Vice-Chancellor, Vishwa Bharati University on the 25th October, 1957.
3. Shri C. D. Deshmukh, Chairman, University Grants Commission, Government of India on the 6th November, 1957.

FINANCE

The financial position of the Academy is shown in the Financial Statement for the year 1956-57 ending on the 31st March, 1957.

We express our deep sense of gratitude to :

1. The University of Allahabad for giving the Annual Grant of Rs. 1,000/- for the year 1956-57.
2. The Council of the National Institute of Sciences of India for its Annual Recurring Grant of Rs. 2,000/- (1956-57).
3. The Government of Uttar Pradesh in the Department of Education for the Annual Recurring Grant of Rs. 6,000/- for 1956-57.
4. The Government of India, Ministry of Natural Resources and Scientific Research for its non-recurring grant of Rs. 10,000/- to meet publication expenses.

We are deeply grateful to the Chief Minister of Madhya Pradesh for reviving our grant for the maintenance of Saugar Branch of the Academy.

Inspite of these grants we have not been able to clear our debts and our publications have also suffered for want of funds. We, however, expect to get more funds this year.

PUBLICATIONS

The proceedings of the Academy continue to obtain marked recognition in India and abroad and during the year under review there has been a great demand for the back numbers of our Proceedings.

The Proceedings of the Academy are published in two Sections—Section "A" (Physical Sciences) and Section "B" (Biological Sciences). From January 1957 to December 1957, the Academy has been able to publish six parts of its "A" Section ane six parts of "B" Section covering a total of 883 pages. The Academy has still to publish four parts of Section "A" and four parts of Section "B" in order to bring the publication upto date. After a long time the Academy has succeeded in publishing its Proceedings of a particular year in the same year and it is expected that slight delay in publication will disappear this year.

EXCHANGE LIST

There are about 180 Foreign Journals on our Exchange list. As mentioned in previous years we are unable to enlarge our Exchange list due to the paucity of our funds.

LIBRARY

The Library needs much improvements but it is not possible to do much in this direction till we have more funds at our disposal. Since 1948, the Academy has been approaching both the Union and State Governments for financial assistance for this purpose but so far we have not succeeded. We, however, hope that the Government will realize the need of a suitable library for this Academy and will sanction sufficient funds for its maintenance and improvement.

AWARD OF U. P. GOVERNMENT EDUCATION MINISTER'S GOLD MEDAL FOR 1957

We have pleasure to announce that Uttar Pradesh Government Education Minister's Gold Medal for the year 1957 for best research paper published in the Proceedings of the Academy (1952-1957) in Zoology has been awarded to Dr. S. M. Das, Assistant Professor of Zoology, University of Lucknow, on the unanimous recomendation of the referees.

GENERAL REMARKS

The Rules and Regulations of the Academy are liberal and democratic and it is, therefore, possible for every person interested in Science to become its members. We are proud to have many eminent scientists and prominent national leaders as Honorary Members. We hope that still larger number will join the Academy in the years to come.

The Academy has succeeded in building a small home for itself with the generous donations from its members and public but we still need more covered space. It is a matter of deep regret that we have not received any financial assistance from the Government for building purposes. The grants from the Government are extremely inadequate and consequently the Academy is unable to publish its Proceedings regularly. We have however, to toil very hard and have every hope that in due course more generous financial assistance will come forth from the public as well as from the State and the Union Governments and this will enable us to contribute our mite to the national progress.

THANKS

We wish to express our thanks to the Scrutineers who have scrutinized our voting papers, to the Judges for assessing the papers for the award of the Education Minister's Gold Medal, to the members of the Academy for their ungrudging help and co-operation throughout the year under report.

Financial Statement showing the actual Income and Expenditure of the National Academy of Sciences, India, Allahabad for the year 1956-57

INCOME	Rs.	a.	p.	EXPENDITURE	Rs.	a.	p.
Opening Balance	3,328	14	3	Establishment	3,140	10	0
U. P. Government Grant	6,000	0	0	Dearness Allowance	879	7	0
Central Government Grant	10,000	0	0	Stamps and Stationery	1,030	8	0
Allahabad University Grant	1,000	0	0	Cycle Repairs	22	0	6
N. I. S. India Contribution	2,000	0	0	Railway Freight	207	7	6
Subscription from Members	1,531	4	0	Conveyance	63	12	0
Life Membership Fee	1,240	8	0	Miscellaneous	1,824	11	0
Bank Commission	9	10	0	Silver Jubilee	137	8	0
Jubilee Account	75	0	0	Gold Medal	145	0	0
Sale of Proceedings	1,336	6	6	Cost of Publication	17,970	11	3
Cost of Reprints	1,439	14	6	Audit Fee	100	0	0
Donation to Accdemy	1,191	10	0	Bank Charges	32	15	0
Recovery of Loan	25	0	0	Other Misc. Expenses	637	4	0
Unspent contingent Amount	248	1	0	Loan	680	13	6
Refund from Government Press	293	11	0	Refund of Loan	1,426	0	0
Loan Taken from Reserve Fund	1,862	3	0	Subscription Returned	20	0	0
				Petty Cash in hand	17	5	9
				Balance at Bank	*3,246	1	3
Total	31,862	2	3	Total	31,582	2	3

*Out of this amount, a sum of Rs. 862-3-0 has to be transferred to the Life-Membership account in respect of Loan taken from that account. Further, a sum of Rs. 1,240-8-0 has to be transferred to the Life-Membership Account. Thus the balance in hand is actually Rs. 143-6-3.

R. N. TANDON
M.Sc., Ph.D., D.I.C., F.N.A.Sc.,
General Secretary,
National Academy of Sciences, India, Allahabad

S. GHOSH
D.Sc., F.R.I.C., F.N.I., F.N.A.Sc.,
Honorary Treasurer.
National Academy of Sciences, India, Allahabad

Examined with the books and vouchers, certified correct, to the best of our knowledge, information, and belief.

(Sd) G. P. JAISWAL
for G. P. JAISWAL & Co.
Chartered Accountants and Auditors, Allahabad

Dated 3rd June, 1957

Twenty-Seventh Annual Session

AT

University of Jabalpur

26th to 28th December, 1957

Pt. Kunjilal Dubey delivering the welcome address.

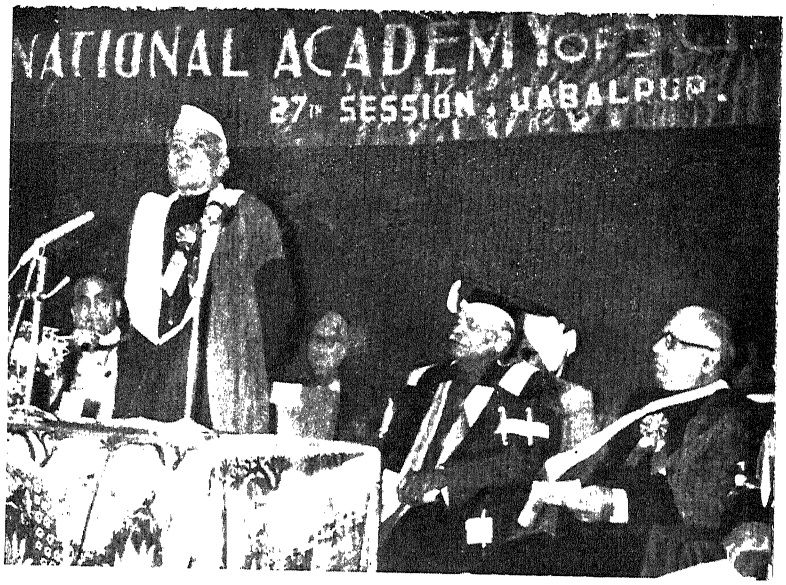
Dr. R. N. Tandon presenting the Secretaries' Report.

Twenty-Seventh Annual Session

AT

University of Jabalpur

26th to 28th December, 1957



Dr. Kailash Nath Katju delivering the inaugural address.

Prof. P. S. Gill delivering the Presidential Address.

PRESIDENTIAL ADDRESS

DELIVERED AT

The Twenty-Seventh Annual Session of the National Academy of Sciences, India, on 26th December, 1957 at Jabalpur

By

Prof. P. S. GILL, Ph.D. (Chicago), F.N.I., F.N.A.Sc.

Head of the Department of Physics, Muslim University, Aligarh

and

Director, Gulmarg Research Observatory, Gulmarg

MR. CHAIRMAN, FELLOWS AND MEMBERS OF THE NATIONAL ACADEMY, LADIES AND GENTLEMEN :

I am deeply conscious of the high honour, the fellows of the Academy have done me in electing me their president. In conformity with the practice initiated by my predecessor, I have divided my presidential address into two parts. The first part deals with the immediate needs of the country in trained personnel in which universities to which the bulk of the fellows of the National Academy belong, can play a decisive role. Part two covers the recent developments in the subject of my own professional interest.

Part I

TRAINING OF SCIENTISTS

It is indeed a pleasure to have an opportunity of presenting a few basic problems facing the country to a distinguished audience of scientists. I hope you will excuse my shortcomings in dealing with a complex topic as the relation of science to national affairs, but the significance of the subject both for the individual and the country, has encouraged me to make an attempt at it.

It is desirable to assess the country's achievements in all phases of our national life since independence. Our national government, under the inspiring leadership of Pandit Jawaharlal Nehru, while facing unprecedented problems of hunger and rehabilitation, embarked on various development plans with a view to put India once again on the map of the world as a free and self-respecting nation. The first five-year plan was launched and came to a successful close. The second five-year plan is now in operation.

Within this short time, India has become an inevitable factor in the world forum in the social and political fields. The same cannot be said about our position in the field of fundamental education and research, in which we lag considerably behind many of the advanced countries. In the field of scientific research we have to make much greater efforts than we have made hitherto. This does not mean that India's progress in these fields is at a standstill. We have made big leaps forward from preindependence days and we can be rightfully proud of them. The establishment of national laboratories and other research institutes throughout the country bears evidence to this fact. Our Prime Minister is one of those rare men of vision who saw that the application of science would be one of the most important factors in improving the living conditions of our people. It is with his moral backing and personal interest that one after another institutes of national importance sprang up since independence. This is no mean achievement. At the occasion of the opening of one of the National Laboratories the Prime Minister said, "The completion of the chain of national laboratories is a very great and historic step in the advancement of our country." To the research workers he pointedly remarked, "So we must see that we do justice to this money which is public money-the money of the people of India."

In discussing scientific research in relation to the National Development Plan, we have to consider the need for research and its effective use in term of the Universities, industry, defence and communications. A plan must have the confidence and full co-operation of all areas of science in the country. I wish to deal with the role which scientists belonging to the universities can play in furthering the national development plan.

It is generally accepted that technology is the natural result of research in science. The age of technology in which we are living to-day has influenced the lives of all men and women to varying degrees. The question worthy of serious public attention with regard to the national policies in research and development can be assessed if we remember the special position which scholarship and higher learning always has occupied in all civilised countries. The scholars devoting their time for research in science were primarily concerned with finding fresh aspects of truth in their particular fields of study. It is an undisputed fact that real contributions to knowledge are made in an atmosphere of freedom, which is supposed to exist in the Universities.

I am conscious of the necessity of having more and more technical personnel to execute in a planned and proper manner our National Development Plans. To produce the required technicians, the Central and State Governments have taken laudable steps to open new and improve the existing technical institutions. The cost of modern scientific and technological research is so great that only an enlightened government can undertake to finance it.

A good deal of applied research has to be carried out under the auspices of agencies of the Government. I wish to emphasize that all this requires a broad basic training to our young students who have to shoulder the responsibilities of research and development of our rapidly expanding economy based on technology in an increasing manner. It implies, therefore, that equal, if not greater, emphasis should be placed on the basic training in the Universities.

It is an accepted fact that all the Universities in this country are now totally dependent on the financial support of the Central or State Governments, as their own resources are limited. There is, therefore, a greater need of vigilance on the

part of the public and the government to allow the natural free growth of the Universities. At the same time it is necessary to evolve a regular systematic assesment of all aspects of our Universities development. Real dangers to the development of science in a democratic country is its support from only one source. In order that best in science can flourish and that freedom in science is preserved, it must be assured that Universities must get support for its research programme from various agencies of the government, industry and philanthropists. There is a grave danger if support comes only from one agency of the government, as the administrative procedure is likely to direct its support in a particular direction. No single research committee or a department head can then affect very profoundly the national scene.

I shall now turn to the part which the Universities can play in the general training of young scientists so essential in country's development. Many of you have long and active associations with the Universities. In training youngmen, you are doing all that is possible with limited means at your disposal, such as inadequate staff and paucity of equipment. But you will agree with me that the conditions under which you are shouldering these responsibilities are far from ideal. In this the major blame should be placed on the administrators of the Universities, some of whom come to the Universities with little or no experience of education. It is a common knowledge that admissions to even post-graduate classes are not made on merit. So many other considerations have the better of our judgment. If it is accepted that training of personnel forms an important pre-requisite for successful execution of the National Development Plan, then we should find ways and means to do this job efficiently. Consideration of power, prestige, parochialism must go if we are to make India strong.

Our Universities under the present state of development of the country cannot afford to establish their own institutes where applied and fundamental research workers can work hand in hand. But such interrelation can be made possible if national laboratories and other governmental institutions and industrial research laboratories can find ways and means to co-operate effectively with the universities. This combination of fundamental researh with applied research will prove beneficial to both. An objective attitude of the fundamental research worker and his method of approach to problems can have a highly stimulating effect on the applied scientist.

May I now turn your attention to the lack of facilities with which educational institutions are faced. First and the foremost is the paucity of well qualified staff. Do our universities have ample staff of higher calibre in all branches of science ? The answer is no. Either the country lacks in qualified personnel or the status of our universities is such that it does not attract qualified men. We have a legacy from the past regime of lure for government jobs for reasons of emoluments, security, position and power which, I am afraid, still persists in free and democratic India. In other advanced democratic nations, this position is different. The best of their scholars and scientists prefer to stay in the universities. We must create similar atmoshere to keep such men in our educational institutions and thus ensure the flow of properly qualified scientific personnel. I do not think that the country lacks in qualified men. Some of our youngmen who had gone abroad for training in various fields of science have done extremely well, but they continue to stay abroad as they find brighter opportunities there. A majority of those who return are attracted to governmental jobs. The posts in the universities are rigidly controlled and limited. Even when a specially trained person does find employment in a department of the university, he finds very little equipment, if at all, to undertake work in his own speciality.

We might compare the facilities which exist in university laboratories of other advanced countries which will give an indication of lack of similar facilities in our universities. A few items of specialized equipment in Physics available in educational institutions in the U.S.A. by the end of 1952 were :

Betatrons	... 4
Cloud Chambers	... 51
Cryostats	... 20
Cyclotrons	... 18
Differential analyzers	... 20
Electrostatic generators	... 34
Linear Accelerators	... 14
Mass Spectrographs	... 46
Synchrotrons	... 6

Our universities do not possess even one-tenth of these items. Granted that most of this equipment is costly, but can it be doubted that these items are essential for purposes of training young physicists ? Similar are the conditions in other branches of science.

In the United States roughly 40% of the fund for nuclear physics is spent in the National Laboratories and 60% is spent in the Universities. Two-third of the basic Physics programme is in the University laboratories, but it is interesting to note that this part of the programme costs only about the same as the other third carried in the national laboratories. According to T. H. Johnson, Director of Research for the A.E.C.—"Often the Universities can do the jobs cheaper and better, and students trained in the programme are an extra bonus to the operation." For these reasons many cyclotrons, betatrons, synchrotrons and Van de Graaffs have been placed in the university laboratories.

On the other hand we find that the achievements of Soviet Science have soared very high. In fact they asked for the moon and have got it. How has that been possible? In the Soviet Union the Academy of Sciences was vested with full power and funds were provided liberally. Their major laboratories for fundamental as well as applied science were set up under the auspices of the Academy of Sciences. It means that the Soviet Union placed full trust in their men of science and respected their decisions. In return the scientists justified that trust.

Academy like ours can in co-operation with the National Institute and other scientific societies play a very decisive role in the fast development of our country.

May I, therefore, make a special plea that our policies ought to be to advance the level of our basic knowledge and to increase the supply of trained men for future work. The national interest lies in providing rescearch opportunities to all educational institutions but the least we can aim in our second Five Year Plan is to provide a few basic facilities for work in our universities. Research activities properly integrated into academic life will bear fruit of incalculable value. Such a programme of research can be considered as an investment which will pay high dividends. On the other hand the research results will contribute to knowledge and at the same time strengthen the teaching programme which will result in better qualified scientific man-power.

Part 2

NEW PARTICLES OF PHYSICS

The discovery of the μ-meson in Cosmic rays by Neddermeyer and Anderson[1] in 1938, three years after Yukawa had postulated a particle of smilar mass ($\sim$200 m_e) to explain the forces responsible for nuclear binding, brought about a new chapter in the physics of fundamental particles. This particle was characterized among other things, by a rather short life-time ($\sim 10^{-6}$ sec.), a feature which distinguished it from the hitherto known particles viz. electerons, protons and neutrons. No time was lost in seeking to identify this particle with the hypothetical Yukawa particle responsible for nuclear forces, though it was soon recognized that a most urgently needed property viz. strong nuclear interaction, was almost entirely lacking in it and the Yukawa particle remained as hypothetical as before. This dilemma lasted till 1947[2] when Powell discovered another cosmic ray particle which was found to decay into simpler products, one of them being identified with the μ-meson itself. In addition this particle was also found to produce frequent nuclear disintegrations in the emulsion plates, indicating that it did have the property of strong nuclear interactions. Thus this new particle was successfully indentified with that of Yukawa's postulation and it marked an important advance in our understanding of nuclear forces. This new particle was called the π-meson. At this stage the list of elementary particles seemed to be almost complete and physicists were generally happy about this state of affairs, in so far as cloud chamber tracks and those in nuclear emulsion plates did not indicate the existence of any further unknown particles, nor was there a theoretical need to postulate any more. However, with the passage of time and with the availability of more sensitive detecting devices many anomalous tracks were discovered[3], which could in no way be reconciled with the hitherto known particles, including the μ- and π-mesons. These tracks had therefore to be attributed to completely different particles altogether. During the last few years a fairly large number of such particles have been discovered in cosmic rays and subsequently produced by means of particle accelerators in the laboratories as well. The theoretical work on these particles so far has been mostly in the nature of a qualitative analysis of some of their important physical characterestics like mass, life-time, spin, parity etc., and the picture to-day is somewhat clearer than it was at the time of their discovery, though it is still far from satisfactory. It is, therefore, not irrelevant to give a brief review of these particles. It was indeed lucky for physicists (both theoretical and exprimental) that these particles were not discovered in the 40's when the picture of nuclear forces was already quite confusing. These particles will be called strange particles in the following:

Strange particles have been broadly classified into two groups:— (*i*) hyperons for which one of the decay products is a proton or a neutron (baryon) and (*ii*) K-mesons whose decay products have been found to have all types of charges $+e$, $-e$ and zero, ($-e$ being the electronic charge). Their masses have been fairly accurately measured. The masses of hyperons vary from 200 m_e to 2700 m_e, and those of K-mesons from 800 m_e to 1300 m_e. The existence of the following hyperons and their decay schemes have been well-established:

(1) Λ° - particle $\rightarrow P + \pi^-$

(2) $\Sigma^+ \rightarrow N + \pi^+$, $P + \pi^\circ$; $\Sigma^- \rightarrow N + \pi^-$; $\Sigma^\circ \rightarrow \Lambda^\circ + \gamma$

(3) $\Xi^- \rightarrow \Lambda^\circ + \pi^-$

The evidence for the existence of Σ^0 is not so clear as it is difficult to distinguish it from Λ^0. Certain decay modes are forbidden. The following K-meson decay schemes have also been well-established :

(1) $\tau^+ \rightarrow \pi^+ + \pi^+ + \pi^-$; $\tau^- \rightarrow \pi^- + \pi^- + \pi^+$

or $\rightarrow \pi^+ + \pi^0 + \pi^0$; or $\rightarrow \pi^- + \pi^0 + \pi^0$

(2) $\theta^+ \rightarrow \pi^0 + \pi^+$; $\theta^0 \rightarrow \pi^+ + \pi^-$

(3) $K_{\mu_2} \rightarrow \mu + \nu$; $K_{\mu_3} \rightarrow \mu^+ + \nu + \pi^0$; $K_{e_3} \rightarrow e^+ + ? + ?$

Thus all strange particles have the common characteristic of decaying into the so-called well-known or "normal" particles. The lifetimes for decay vary between 10^{-8} sec. and 10^{-10} sec. Such long lifetimes (compared with those for nuclear interaction, *viz.* $\sim 10^{-21}$ sec.) are unusual except when the decay products are those having weak nuclear interactions like muons and neutrinos. Though some of these particles do have such decay products, e. g. K_{μ_2}, Ke_3 etc., there are others whose decay products are purely nuclear particles (pi-mesons and nucleons) as in the case of hyperons, τ - and θ - mesons. Thus one of the earliest "strange" particles to be unambiguously identified - the Λ^0 - particle - decays into a proton and a π - meson with life time $\sim 10^{-10}$ sec. To reconcile such facts with any known theory of nuclear interaction has presented one of the most baffling problems in the physics of fundamental particles.

The earliest explanation that was offered was that a large centrifugal barrier acting between the decay products might be responsible for such unusually long life times. However, this concept was found to contradict the elementary nature of such particles and was soon abandoned. The explanation which is now generally accepted is one due to Gell-Mann[4] and Nishijima and is based on the concept of a hitherto unknown quantum number, called "Strangeness" (S). According to these authors, each fundamental particle has an integral value of S associated with it. For the normal particles the value of this quantity is zero, but for the "strange particles" its value can vary from - 2 to 1. Strong selection rules are assumed to operate for a transition which changes the value of S. Strong (nuclear) interactions and electromagnetic interactions conserve the value of S and such reactions proceed very fast. On the other hand, for weak (decay) interactions $\Delta S \geqslant 1$ and these, therefore, proceed very slowly, the larger the change the slower the process. This hypothesis provides a very natural explanation for the long life times of hyperon and K-meson decays since for the process $\Lambda^0 \rightarrow \pi^- + P$, for example, $\Delta S = 1$.

The above hypothesis serves equally well for another important observation, viz. that in a nuclear reaction, these strange particles are copiously produced in associated pairs, though certain combinations are not found. An obvious way to ensure fastness of a nuclear reaction in which an associated pair is produced is to assign equal and opposite values of S for the two members of the pair so that their sum vanishes and the net ΔS can thus be made zero. A good example of such a process is $\pi^- + P \rightarrow \Lambda^0 + \theta^0$, which is satisfied if S has the value ± 1 for Λ^0 aud θ^0 respectively. In this way it has been found possible to assign unambiguous values of S to all the strange particles discovered so far, in such a way that they do not contradict any known observation involving their associated production.

It may now be said that so far as a qualitative understanding of the decay life-times and associated production of strange particles is concerned, the picture is fairly clear. However, there are still many important details of observation

which remain unexplained. One such problem is provided by the so-called τ - θ^0 anomaly. The masses of these two particles are almost exactly equal, but their life-times differ by a factor of about 100. The postulation that these two particles are one and the same leads immediately to the contradiction that their decay products have opposite parities (τ decays into three pions and θ^0 into two.) which fact cannot be reconciled unless it is assumed that parity is not conserved during a decay process. This revolutionary concept of parity violation seems to strike at the very root of the foundations of Physics which are based on the cherished conservation laws of energy, total angular momentum and parity. Yet this was the very idea which was boldly put forward by Yang and Lee[5] who even suggested some simple experiments on the conventional β - decay in nuclei to test it. Curiously enough the experiments which have been carried out are completely in agreement with the Lee-Yang hypothesis of parity violation which is now generally accepted. The idea of parity is so basic and revolutionary that its authors, Lee and Yang, have been awarded the Nobel Prize for Physics this year within one year of the appearance of their first paper. The only consolation which physicists can derive from this uncomfortable situation is that parity is violated only for weak (decay) interactions, but remains fully conserved for strong and electromagnetic ones. Unfortunately this hypothesis has not yet been able to answer the problem of the τ - θ^0 anomaly for which it was intended, though it has gone a long way towards predicting many more interesting results on electron polarization in β-decay processes which can easily be checked with available equipment.

One can thus infer that a detailed study of the behaviour of these strange particles can throw very valuable light on important theoretical questions which have a much wider bearing than the limited sphere of these particles. In other-words, the very 'strangeness' of these particles is the secret to a deeper understanding of nature itself.

In more recent times experiments with the huge particle accelerator at Barkeley have led to the discovery[6] of two important particles which, unlike the strange particles, were long expected by physicists on the basis of Dirac's celebrated theory of the electron and the positron. The discovery of the anti-proton and subsequently of anti-neutron may indeed be regarded as a landmark in the understanding of nature, in so far as the "Dirac" character of these particles has now been conclusively established.

TABLE I (Hyperons)

Hyperon	Decay mode	Q-value in Mev.	Mass	Mean life (sec)	Strangeness
Λ^0	$P+\pi^-$	37	2181 ± 1	$3{\cdot}7+10^{-10}$	-1
Σ^+	$N+\pi^+$ $P+\pi^0$	110 —	2327 ± 3	$\sim1+10^{-10}$ —	-1
Σ^0	$\Lambda^0+\gamma$	—	2323	Short	-1
Σ^-	$N+\pi^-$	110	2320 ± 10	$\sim2+10^{-10}$	-1
Ξ^-	$\Lambda^0\ \pi^-$	~67	2581 ± 10	$\sim1+10^{-10}$	-2

TABLE II (K-meson)

Meson	Decay Mode	Mass	Mean life (sec)	Strangeness
θ°	$\pi^{+} + \pi^{-}$	All K^{+}, K° have masses $\sim 966 \pm 10\ m_e$	$1{\cdot}7 \times 10^{-10}$	+1
$\theta_2{}^{\circ}$	$? + ? + ?$			
$K^{+} \equiv \tau^{+}_{\pi_3}$	$2\ \pi^{+} + \pi^{-}$			+1
τ^{+1}	$2\ \pi^{\circ} + \pi^{+}$			+1
$K^{+}{}_{\pi_2}$	$\pi^{+} + \pi^{\circ}$		$1 \times 10^{-8} \pm 20\%$ is the life of all K^{+} - mesons	+1
$K^{+}{}_{\mu_2}$	$\mu^{+} + \nu$			+1
$K^{+}{}_{\mu_3}$	$\mu^{+} + \nu + \pi^{\circ}$			+1
$K^{+}{}_{e_3}$	$e^{+} + ? + ?$			+1

REFERENCES

1. Neddermeyer and Anderson, Phys. Rev. 54, 88, (1938).
2. Powell et al Nature 160, 453, (1947).
3. The earliest event of an anomalous "V" track was reported by Rochester, G. D. and Butler, C. C., Nature 160, 855 (1947).
4. M. Cell-Mann, Report of the Glasgow Conference on High Energy Physics, 1954, Pergamon Press, London.
5. T. D. Lee and C. N. Yang Phys.. Rev. 104, 254 (1956) and subsequent papers.
6. Chamberlain, et al Phys. Rev. 100, (1955).

CHEMICAL REACTIVITY AND LIGHT ABSORPTION

PRESIDENTIAL ADDRESS

DELIVERED AT

THE PHYSICAL SCIENCES SECTION DURING THE TWENTY-SEVENTH ANNUAL SESSION OF THE NATIONAL ACADEMY OF SCIENCES, INDIA

On 27th. December, 1957 at Jabalpur

By

PROF. A. K. BHATTACHARYA, D.Sc., F.R.I.C., F.N.A.Sc.

Head of the Department of Chemistry

University of Saugar

MEMBERS OF THE ACADEMY, LADIES AND GENTLEMEN,

I am extremely thankful to the Council of the National Academy of Sciences for electing me as the President of its Physical Sciences Section this year. I am fully aware of inability and incapability in fulfilling the difficult task to which I am put ; but with the co-operation of you all I am sure that I shall not fail in my attempt to make this a success. The presence of learned and distinguished fellows and members of the Academy makes me more confident in my task.

Let me take this opportunity of congratulating the authorities of the Jabalpur University, especially the eminent Vice-Chancellor for the willingness with which they came forward to have the 27th annual session of the National Academy of Sciences here. For us who hail from Saugor it is a matter of great joy that one of our youngest sister Universities is prepared to come forward to help the cause of science. Only with such help and encouragement scientific research can advance in any country. Let us hope that this encouragement will countinue for ever.

Now, to come to the subject matter, it is known that chemical reactivity is a complicated affair in which several independent effects participate. For the matter of that it does not easily lend itself to any type of simplification. Nevertheless certain general principles begin to appear from time to time, and although it would be too optimistic to claim that they can enable us to predict every thing about a reaction it is probably fair to say that some of them give an insight into the processes of a primary chemical combination. One such principle concerns the light absorption by molecules during interaction.

It is now certain that in many cases of ordinary reactions, primary association complexes are first formed afterwards yielding the normal products of reactions. From the point of view of an Eyring—Polanyi potential energy diagram for the reactants and products in a simple bimolecular reaction, it is clear that the magnitude of the activation energy and formation of the activated complex are conditioned by various factors. They include the bond strength of the reactant

molecules, the repulsion of the atoms in the reactant molecules, the bond strength of the new links in the products formed and the repulsion between the various product molecules. We may therefore speak of the activation energy as consisting of two parts : reagent repulsion energy or simply repulsion energy and bond stretching energy. This breaking and making of new bonds thus involves changes of energy in the molecules. The influence of such changes on their light absorption has attracted the attention of a good number of workers. Certain ideas about the light absorption changes resulting from the changes in bond lengths during molecular interaction have been entertained since a long time.

Weigert[1] had stressed the influence of deformation on optical and photochemical properties and suggested that every chemical process may be regarded as a consequence of a primary polarisation or displacement of an electron. In this case, changes in the electrical configuration of molecules during interaction were considered important in effecting a change in light absorption. Jones and Strong[2] indicated a possible method for detecting the presence of intermediate compounds in chemical reactions by light absorption studies. Later Von Halban[3] studied the influence of electrostatic forces upon the magnitude of the extinction coefficients in various solutions and the effects of adding foreign non-absorbing salts. Schiebe[4] was the first to apply such studies to chemical equilibria. He indicated the possibility of relationship between the displacement of absorption bands and the rate of equilibrium of chemical reactions. The possibility of an experimental detection of the deformation of molecules during reaction was thus given.

Henri[5] in 1913 published a paper on the application of spectroscopy to the study of chemical equilibria wherein he showed that the mixture of oxalic acid and uranyl salts had more light absorption than either of them. A kind of relationship between the photocatalytic power of uranium salts and this enhanced absorption was attempted. This observation is very important because of Henri's statement that the general rule is that chemical lability always enhances the absorptive power for ultraviolet rays. It is this chemical lability that is connected very closely with the binding strength of a molecule. It appears therefore that when there is a loosening of the bond, there must ensue an increase in light absorption. In a series of homologous molecules where the binding strength is known to change, Lowry and Ross[6] have shown that the extreme limit of the general absorption is shifted to longer wavelength as the binding strength decreases. In mixtures, however, such studies were few. J. C. Ghosh and collaborators[7] carried out important quantitative measurements of the extinction coefficients of uranyl salts, ferric salts, and mercuric salts with formic, acetic, oxalic and other organic acids and showed that a chemical complex is formed which enhances the light absorption in the ultraviolet. In all cases of photosensitisation, the molecules are sensitised to longer wavelengths. The chemical complex theory of photosensitisation involves the formation of a new additive compound. It is not however clear whether this increased absorption is due to the new compound or to the weakening of the binding forces of the sensitised molecule itself.

The raising of temperature is known to increase the vibration of molecules and increase their potential energy which also means that the bond is loosened. Henri and Lasraff[8] and Walls and Ludlam[9] showed that increase of temperature in methylamine vapour, and acetone in water and methyl alcohol displaced the absorption bands to longer wavelengths. Dutta's work[10] on molecular absorption spectra of gases in presence of foreign gases also subscribes to the same view. Again, the work of Frolich and Sack[11] on the photoelectric effect of adsorbed layers indicates the same idea.

Thus it appears that strong views have been held in support of the idea that the loosening of a bond may enhance light absorption. Since it was agreed on all sides that during a bimolecular reaction, a stretching in the molecule happens and a gradual weakening of the bond occurs before it completely transforms into a new bond, increase in light absorption during the primary process of a chemical reaction was anticipated. The energy of activation being of the nature of the vibrational energy, the required energies of excitation by light quanta was also expected to be changing. With this theoretical reasoning in the background, Bhattacharya and Dhar[12] took up the experimental study of various reactions. From a study of a series of reactions involving chlorine, bromine, iodine, chromic acid, potassium permanganate, silver nitrate, mercuric chloride and hydrogen peroxide with reducing agents we could draw some important conclusions. In all the cases considered it has been found that, in general, an increase in the light absorption by a molecule is associated with its increased chemical reactivity and weakening of the binding forces and conversely when a molecule becomes more reactive, it is likely to absorb light more markedly. Increase of temperature enhances the amount of light absorption and activity of the molecule and it decomposes on illumination by radiations of longer wavelengths. The presence of hydrogen sensitises the dissociation of chlorine molecules and makes them reactive in radiations of longer wavelengths. The addition of an oxalate markedly sensitises the decomposition of iodine molecules and they are activated in the dark and in radiations of longer walvelengths. The absorption of light by a solution of an oxalate is appreciably increased by the addition of dilute iodine solution.

In presence of uranium nitrate, ferric chloride or mercuric chloride, the light absorption and photo-decomposition of organic acids are greatly increased. When manganese salts are added, the light absorption by mixtures of organic acids and chromic acid or potassium permanganate is increased and the oxidation of the organic acids by chromic acids or potassium permanganate is also accelerated.

In presence of reducing agents like hydrogen, carbon monoxide, ferrous salts, nitrite, hydroxylamine, hydrazine, alcohols, acetone, organic acids and their salts etc., the halogen molecules become reactive even in the dark and in radiations of wavelengths longer than those necessary for their sensitised or photochemical dissociation, because the binding forces of the halogen molecules are considerably weakened due to the reducing agents. The presence of water may sensitise the photo-decomposition of some substances by weakening the binding forces and increasing the light absorption. It appears that the first stage in a reaction between two or more molecules, is the formation of an additive product with weakening of the linkages and increased light absorption. This is likely to happen in thermal as well as photochemical reactions. The increased light absorption appears to be due to the activation of the molecules by the presence of the molecules of other substances. The activation of the molecules is associated with the weakening of their binding forces and consequent increased light absorption.

The observation of Weigert and Kellermann on increased light absorption by a mixture of chlorine and hydrogen and the increased light absorption observed by Ghosh and collaborators with mixtures of Fehling's or Benedict's solutions and mixtures of reducing agents, and the observations of Fajans on increased light absorption by silver halides containing adsorbed silver, have been explained from the view point that the chemical reactivity of these various systems is associated with the weakening of the binding force. The reactions with greater velocity appear to show greater light absorption than those with smaller velocities. Other publications by Mukerji and Dhar[13] and Dhar and Bhargava[14] emphasised the same hypothesis.

In all the above cases it was not possible however to find quantitatively the extent of this enhancement. The method adopted wass pectrographic. The spectra obtained were mostly continuous ones with some cases of selective absorption also and hence it was difficult to say where the absorption exactly begins. Thus only the approximate location of the bands could be made. Further the spectral strips could only indicate whether there was any shift in the region of continuous absorption. Of late the theories of light absorption make a definite distinction between the shift in the absorption maxima and increase in light absorption at a particular wavelength range. This differentiation could not be made on the instantaneous photographs taken in the earlier methods.

Modern improvements in the technique of taking the absorption spectra can help a great deal in these investigations. Spectrophotometric means can easily give a much clearer picture of the changes involved in a more quantitative way. It is also realised that in solution systems the factors affecting light absorption are too many and that great precautions are to be taken before coming to any final conclusions regarding the results. The influence of the products of the reaction must, to a great extent, be considered in such studies. The earlier workers have assumed that the products formed in the first few seconds are nil and have taken the changes in absorption as due entirely to the physical forces discussed earlier. Since the light absorption changes in the succeeding stages of the reactions could not be shown, this effect cannot be ignored. So it remains to be seen what happens to light absorption in the various stages of the reaction. The changing concentration of the reactants and the accumulation of the intermediate and the final products must be taken into account. For this a detailed study of the reaction in all its aspects was necessary and every possible explanation for the observed changes, from a simpler and more direct interpretation of the results, must be tried before the theories of loosening of bonds and light absorption are applied.

With these ideas in view Subbaratnam and Bhattacharya undertook a detailed investigation of the course of various chemical reactions by measuring the absorption at their various stages, with particular reference to changes in extinction at the maxima of the reactants and possible formation of a new absorption band. The reactions studied were those involving iodine and reducing agents like sodium formate, potassium oxalate, sodium citrate, sodium tartrate, sodium nitrite, ferrous sulphate, formic acid, acetic acid, oxalic acid, citric acid and potassium iodide; chromic acid and formic and oxalic acids; potassium permanganate and oxalic and citric acids; and uranyl nitrate and oxalic acid.

By following the changes in the absorption spectra of the various reactions we could arrive at some interesting results. In the case of iodine and potassium iodide the small addition of potassium iodide decreases the absorption in the visible up to 430 $m\mu$ with the complete disappearance of the maxima in the visible range. But in the ultraviolet there is an increase in absorption and a flattening of the maxima at 350 $m\mu$ and 290 $m\mu$. Further additions of potassium iodide result in an increase even in the visible. In the ultraviolet the absorption becomes complete. Addition of potassium iodide has therefore obliterated the maxima at 460 $m\mu$. Thus the band as a whole in the visible can be said to move towards the ultraviolet. These changes are explained as due to the formation of I^-_3 ions according to the equilibrium $KI + I_2 \rightleftarrows KI_3$. The various changes observed in the case of reactions with iodine have been explained from this view. In most of these cases it is seen that there is an increase in absorption in the ultraviolet. But at the same time there is a corresponding decrease in absorption in the visible. This at once suggests the formation of triiodide ion and the disappearance of molecular iodine. It can now

be seen why there are peculiar changes in the different reactions. In the fast reactions, like sodium formate—iodine and potassium oxalate—iodine reactions, there was only a decrease in 460 mμ and an increase in 350 mμ and 290 mμ in the initial stages. If this change can be ascribed to the formation of I^-_3 ions it is easy to explore further. The salts of organic acids react with iodine to form iodides :

$$I_2 + HCOONa \rightarrow NaI + HI + CO_2$$

$$I_2 \quad K_2C_2O_4 \rightarrow 2\ KI + 2\ CO_2$$

These iodides immediately set up the equilibrium—

$$I_2 + I^- \rightleftarrows I^-_3$$

The faster the production of iodides or hydroiodic acid, the quicker will be the formation of triiodide ions which will give rise to an increase in absorption at 350 mμ and 290 mμ. But it is clear that the I^-_3 ion formation cannot go on indefinitely because this would demand an indefinite supply of free iodine. When all the molecular iodine has reacted with the salt, the equilibrium $I_2 + I^- \rightleftarrows I^-_3$ will have to be disturbed in such a way that it yields more free iodine to react with the salt. This will result in a decrease in the concentration of I^-_3 ions. It is because of this that a decrease in absorption is found even in the ultraviolet after the reaction has reached a certain stage. Thus the concentration of molecular iodine and the triiodide ion alone seems to be responsible for the changes in absorption.

In the slow reactions with sodium tartrate and sodium citrate the increase in absorption in the ultraviolet must be also due to the production of I^-_3 ions but this seems to be very slow, which is in keeping with the fact that the reactions by themselves have a small rate. In the later stages the extinction in the ultraviolet decreases which is again slow because of the slow production of I^-_3 ions and the slow reaction between iodine and these salts. Coming now to very slow reactions of organic acids with iodine, it is found that the decrease in the visible is very slow with a correspondingly slow increase in the ultraviolet. The peculiar decrease in absorption in the ultraviolet in the initial stage, in contrast with an increase in the case of fast reactions, is due to the reaction rate here being very slow as to produce only very small concentrations of I^-_3 ions after a long time at a low rate. In fact some of the original amount of I^-_3 ions already present as a result of the hydrolysis of iodine appears to have been lost because in the reaction between the acids and iodine, the equilibrium $I^-_3 \rightleftarrows I_2 + I^-$ has to be disturbed in such a way that more free iodine is ready for the reaction. At first the molecular iodine reacts with the acid and it is only after sufficient acid has reacted that we find an increase in extinction in the ultraviolet. In the initial stages therefore even the existing concentration of I^-_3 ion has decreased. The same may occur in other reactions as well but because of the fast rate of the subsequent reaction with the salt immediately producing considerable amounts of I^-_3 ions, the initial drop in absorption even in the ultraviolet is not evident.

Another important point to note is the small increase in absorption in the region 580 mμ to 560 mμ in some reactions. This has been observed only in the case of the fairly fast reactions with the salts. The small increase in this region may be because of the longwave descending part of the I^-_3 ion curve which is slightly above the molecular iodine curve in this region as computed by Awtrey and co workers [15]. The immediate and quick formation of a large amount of I^-_3 ions in these fast reactions is perhaps responsible for this. The absorption in this region is the sum total of the absorption primarily due to molecular iodine and a little due to the I^-_3 ion. But after some time when molecular iodine begins to

decrease in concentration, the absorption in this region also tends to decrease. This is not found in the case of slow reactions with acids where I^-_3 ion formation has been shown to be too slow.

Thus in all these cases of iodine reactions, we have found some new features regarding the changes in absorption during molecular interaction by means of spectrophotometric methods. The results have been more quantitative than those obtained by the earlier workers by photographic methods. Instead of concluding our observations at the initial stage, the entire reaction was pursued with a view to seeing the concurrent changes in light absorption. We have found that the increase in absorption reported to be universal in all reactive substances by earlier workers is observed only in the ultraviolet and that too with limitations. In the visible, there is only a decrease throughout the course of a reaction but for a small increase in the initial stages in some reactions in the range 580 $m\mu$ to 540 $m\mu$ for which an explanation has already been given. No new peak formation was observed anywhere except in the case of sodium chloride-iodine reaction. In all the reactions the increase in absorption in the ultraviolet in general gradually rises to a certain stage wherefrom it begins to decrease. All these observations could be adequately explained by the fact that the I^-_3 ion formation and the removal of molecular or free iodine are responsible for them. It can therefore be said with a reasonable amount of certainty that the increase and decrease in absorption in these cases are mostly concentration effects. These are all new observations which can give a new turn to the ideas about chemical lability and light absorptive power in the ultraviolet which were arrived at by earlier workers mostly from the conclusion that in such reactions at the initial stages the enhanced absorption is due to the loosening of the binding forces.

In the case of permanganate reactions the increase in absorption is explained as due to manganic complexes or colloidal precipitates. In the case of chromic acid reactions there is a clear tendency only for a decrease in absorption. This is a natural consequence of the decrease in concentration of the absorbing reactants. The increase in absorption in the case of uranyl nitrate reaction is explained as due to a clear formation of a new complex. Thus it has been found in general that the increased absorption is observed only when the products have greater absorption in the region or when a new absorbing complex is formed.

From the electromagnetic theory of light and the quantum theory of atomic spectra it is now well understood that electrical changes in the molecule or atom are highly responsible for light absorption. Wave mechanical considerations give now a clearer picture of these changes and explain why certain changes are allowed and others not. For an atom to absorb radiation, there must be a change in dipole moment e. g. when the electromagnetic radiation in the form of a plane polarised wave falls on an electron in an atom or molecule the wave formation of the electron is set into oscillation by the electric vector of the wave. Considering the change 1 s $\rightarrow$ 2p in H atom, the alternate to side oscillation of the 2 p wave, with its separation of negative charge into two halves, endows the atom with a dipole moment which it did not have in the 1 s level. Unless a dipole moment of this kind is generated or destroyed, electromagnetic radiations cannot be absorbed or emitted. In such permitted or allowed transitions, symmetry considerations weigh much. Forbidden transitions can become partly permitted and correspond to weak spectral bands, when symmetry of atomic levels is distorted by neighbours or intense fields. It is therefore from this modern concept that the disturbance of the energy level arrangements due to polarisation by a foreign perturber is of great significance in the change in intensity of absorption lines or in the appearance of new ones. Purely physical forces will be able to explain in many cases the changes in light absorption observed.

Changes in light absorption are known to occur event in the infra red due to the effect of pressure and added foreign substances. Studies in the predissociation spectra of molecules also open up another field in which changes in light absorption are promoted by various influences. The increase of temperature displaces the limits of predissociation in many cases towards the visible region and the the radiations of the region of predissociation causes photochemical reaction or chemical sensitisation of the molecules. There are numerous examples in which simple molecular absorption spectra of gases shift towards longer wavelength as a result of increase in temperature. To say that the continuous absorption band moves to the longer wavelength is the same as saying that the extinction is increasing in the ultraviolet. It appears from this shift that increased temperature of molecules sensitises them towards decomposition to longer wavelength. The potential energy of the systems and the vibrational level of the molecule thus seem to have a larger role in effecting a change in the light absorption.

When we talk of potential energy changes in a molecule and their effects on light absorption, particular attention must be given to the effect of adsorption on light absorption. Differences have been often reported in light absorption observed between free and adsorbed molecules of the same substance. For example, adsorption of Ag^+ ion in the case of AgI causes the intensity of the whole band to be increased markedly. Even the photo-electric effect on adsorbed films afford an analogous picture. Absorption of light by metals causes electrons to jump to higher energy levels and at sufficiently short wavelengths they may gain enough energy to leave the surface.

Theories on heterogeneous catalysis can be traced here to give an analogous explanation to such phenomena connected with light absorption. It is well known that the bonds in the molecules adsorbed on a surface are a little strained in the case of chemisorption where some kind of loose chemical combination between adsorbing material and the adsorbing substance exists. Because of the formation of a surface compound and the resulting strain in the bond, one should expect an increased activity in such cases. Also Burke's explanation[16] for heterogeneous catalysis falls in line with this. The molecule is supposed to be attached to a surface at more than one point whereby a distortion or partial separation of its atoms is produced. Such a distortion is thought of as lowering the activation barrier and facilitating decomposition. It is interesting to explore how this happens. The formation of a relatively strong attachment between parts of the reactants and the surface atoms results in the loosening of the bonds in other parts of the molecules ; a smaller amount of energy is then required to form the activated complex which is a necessary intermediate in the reaction. In our opinion this increased reactivity on adsorption is reflected in the absorption spectra also. The analogy between heterogeneous catalysis and light absorption of absorbed molecules is very close. Because of the strain in the molecule and the loosening of the bonds, it is now in a position of greater potential energy. For light absorption and excitation, now radiations of lower frequency will do because of the raised energy in the ground state itself.

The latest view of Polanyi[17] regarding bimolecular reactions include the formation of a transition state and an electron switch. In a reaction $Ax + B \rightarrow A + xB$ he assumes a strain in the bond A - x up to a point where x has approached B so closely that it can switch over without further supply of energy to form x - B bond. Thus there is a continuous stretching of the bond A - x. It is therefore possible to speak of the activation energy as consisting of simply reagent repulsion energy and bond stretching energy i. e., that required to overcome th e repulsion of the approaching agent and that required to weaken the existing bond. Weaken-

ing of the bond is continuously proceeding as the molecule reacts with another. Approximate estimates of the dimensions of the activated complex by purely empirical methods show that in the activated molecule the length of a bond is increased by about 10% of its normal value. It is of interest to call attention here to the fact that we arrive here to a place where we can try to correlate the relation between bond length and bond strength, and their subsequent relation with light absorption.

The bond length is closely associated with bond energy. Where the bond length is great, the bond energy is less and the dissociation energy is therefore less; there occurs a photochemical dissociation in longer wavelengths in the case of weak bonds. Thus the weakening of the bond should make the molecule easily excitable for radiations of long wavelengths. This need not be pictured as a reverse effect of photochemical excitation. The loosening increases the strain in the molecule and therefore the potential energy of the system may be looked upon as having increased due to this. Now the ground state being at a higher level than the normal molecule, it is possible to excite the molecule more easily. In other words, there is a decrease in the energy of excitation.

It is therefore established that the weakening of a bond enhances the light absorption due to a decrease in the energy of excitation. It is also shown on empirical grounds that during molecular interaction, there is a bond stretching and an increase in bond length by about ten per cent in the activated molecule. But to put those two things together and to say that during molecular interaction, this will utimately result in enhanced absorption, seems now to present great difficulties for very little is known about the strengths of bonds under reaction conditions. Also the activated complex must be of extremely short life and of low concentration at any one stage that it is perhaps impossible to detect its presence or its effect by light absorption methods.

Let me once again thank the council of the National Academy of Sciences for having given me the honour of presiding over the Physical Sciences Section of this learned Academy.

REFERENCES

1. Clark, D. ... The Fine Structure of Matter, Vol. II.
2. Jones & Strong ... J. Amer. Chem. Soc. 43, 224 (1910).
3. Von Halban ... Trans. Farad. Soc. 21, 620 (1926).
4. Schiebe ... Ber. 60B, 1406 (1927).
5. Henri ... Compt. Rend. 158, 181 (1913).
6. Lowry & Ross ... J. Chem. Soc. 622 (1926)
7. Ghosh, J. C. & Coworkers ... J. Ind. Chem. Soc. 4, 353 (1927); 5, 191 (1928); 5, 569 (1928).
8. Henri & Lasraff ... J. Chem. Phys. 32, 353 (1935).
9. Walls & Ludlam ... Trans. Farad. Soc. 33, 776 (1937).
10. Dutta ... Ind. J. Phys. 22, 51 (1948).
11. Frolich & Sack ... Proc. Phys. Soc. 59, 33 (1947).
12. Bhattacharya & Dhar ... Z. anorg. Chem. 176, 372 (1928); 219, 348 (1934). J Ind. Chem. Soc. 11, 1,33 (1934); 11, 5,311 (1934).
13. Mukerji & Dhar ... J. Phys. Chem. 32, 1308 (1928); 33, 850 (1929).
14. Dhar & Bhargava ... Nature 134, 848 (1934).
15. Awtrey & Coworkers ... J. Am. Chem. Soc. 73, 1842 (1951).
16. Burke ... Proc. Nat. Acad. Sci. (U.S.A.) 14, 470 (1928).
17. Polanyi ... Endeavour 8, 29 (1949).

PLANT ECOLOGICAL STUDIES IN MADHYA PRADESH

PRESIDENTIAL ADDRESS

DELIVERED AT

THE BIOLOGICAL SCIENCES SECTION DURING THE TWENTY-SEVENTH ANNUAL SESSION OF THE NATIONAL ACADEMY OF SCIENCES, INDIA

On 27th. December, 1957 at Jabalpur

By

PROF. R. MISRA, M.Sc., Ph.D., F.N.I., F.N.A.Sc.

Professor & Head of the Department of Botany
Banaras Hindu University

LDIES AND GENTLEMEN,

I am thankful to the Council of the National Academy of Sciences, India for nominating me the President of Biological Sciences Section of the current Session. It has given me, besides honour, an opportunity to talk to you about my experience of ecological studies extending over a period of ten years in Madhya Pradesh. This State is exceptionally rich in fauna and flora in contrast to the sparse human population. The rugged country, in addition to the geological and biological wealth, gives rise to a number of rivers, which irrigate also the neighbouring States. Here, as elsewhere, water, soil and vegetation conserve each other This equilibrium gets locally disturbed by man's exploitation of the forest cover which opens the soil to erosion, and when both forest and soil are gone water too is lost. The rapid runoff of storm water during monsoon causes flood in the river systems which may have serious repercussions on the neighbouring States. Hence it is often realised that Madhya Pradesh on account of its physiographic conditions, should maintain the present forest cover, which amounts approximately to 40% of the land surface.

1. INTRODUCTION

Geologically the State represents a very ancient and stable land system, which in prehistoric days should have been entirely covered with dense forests of *Shorea robusta* in the east and deciduous mixed forests of *Terminalia tomentosa—Diospyros melanoxylon—Butea monosperma* in the rest of the State. With the rise of pastoral and agricultural civilisations man might have cleared the forests, locally but regeneration in these areas must have been quick. However, the real menace to the forests

should have arisen upon establishment of villages and permanent agricultural holdings, together with increase in human population. Subsequent growth of a civilisation based on wood and other tree products must have accelerated the denudation of the forests, which necessitated their management in recent years.

One major effect of the denudation of the primeval forests has been loss of soil and moisture from the hills to the valleys. The latter have since been intensively cultivated leaving the exposed rocks of the hills for the vegetation to regenerate. By now the biotic pressure from the valleys upwards has been thinning the forests on the hills almost everywhere causing extensive gully erosion. Thus a large part of the landscape has developed into open scrub jungle of *Butea monosperma*, *Acacia leucophloea*, *A. arabica* and *Zizyphus* bushes filled up with rolling monsoon grasslands. Indeed very little of the primeval forest is now left, such as that of *Shorea robusta* in Baster. The protected forests or those found on inaccessible hills are mostly secondary in origin. It is obvious, therefore, that the variety of plant habitats obtainable today is a product of man's activities in the past.

In early days when botanists were generally engaged in collecting and naming plants, and agriculturists' interest was confined to the conditions of crop production, the foresters got concerned with the teak—the best timber of the world. Brandis described the teak forests in 1876-77 and wrote extensively on Bori reserves at the time when the Government took over the forests. After a long silence, Troup (1921) produced his famous work on the silviculture of Indian trees. Champion (1936) made an attempt to classify the forests and much was written on teak forests even before by Vahid (1927), Hamilton (1930), Laurie (1931), McDonald (1940), Hewetson (1941), and Lauri and Griffith (1941). Similar accounts of other forests were given by Harlow (1937) and Mobbs (1941). However, most of the work was purely descriptive and exploratory.

The establishment of Saugar University and a school of ecology in it gave a fillip to the much needed ecological studies in the State. A number of colleagues, students, members of the State Forest Department, and the ecologist to the Govt. of India pooled their resources together in tackling a series of difficult ecological problems. The results of their investigations carried out during the last decade are very briefly given in the following pages.

2. ECOLOGY OF TREES AND FORESTS

Teak and sal, the two principal timber trees, have been the pivot of most ecological researches in forestry.

Bhatia (1954, 55, 55*a*, 55*b*, 56) undertook a detailed study of *Tectona grandis* and its forests. The tree does not occur naturally in pure crops and is associated generally with base rich substrata. Hewetson (1941) had suggested that a higher moisture content of basalt favoured the growth of teak on this rock. Kulkarni (1951) thought acidic conditions of Gondwana sandstones prevented its occurrence on them. Puri (1951) had no doubt suggested that teak is a calcicolous species occurring on base rich soil, but it was for Bhatia (1954) to demonstrate that the incidence of the species depended upon a minimum level of exchangeable calcium in the soil whatever be its origin. Thus, it was shown by him that many of the

acidic soils bearing good teak growth contained more than 0·39% of exchangeable calcium which is much above the critical level. However, at Allapali (S. Chanda division) teak grows on base poor substrata (soils derived from granite, gneisses and quartzites). According to Bhatia (1956), the final explanation of teak distribution lies in an investigation of the mineral uptake and physiologico—ecological behaviour of the species. In fact Bhatia (1955a) found a very high calcium content (3 - 6%) in teak leaves and characterised the plant as a calciphyte. Nevertheless, his (1955*b*) results showed an equally important role of phosphorous in the mineral economy of the plant. It may be mentioned here that the phosphorus rich mineral apatite may constitute as much as 1% of trap rocks. Unfortunately, Bhatia's life was cut short in Cambridge and the work remains incomplete today.

Bhatia's (1956) study clearly shows that teak makes a heavy demand on soil calcium and phosphorus. Unless these elements are returned from the plant to the soil, it may result in serious impoverishment of the substratum under a teak crop. Brandis (1921) observed deposits of calcium phosphate in the wood of teak and it is clear that on account of heavy exploitation of timber, a good amount of this salt is presumably lost to the soil. In an open teak-forest or in a stand on sloping land there is every possibility of loss of the lime rich litter by wind, runoff and intensive monsoon leaching.

The low sociability of *Tectona grandis* in the forests was considered by Bhatia (1956) to be on account of its heavy calcium demand. However, this matter needs further investigation and the answer may lie in the community economy of teak forests and the biological equipment of the tree at the sapling stage.

S. D. N. Tiwari (1954) reported successful invasion of teak in Sal forests of Bastar presumably upon introduction by man. Plantations elsewhere have proved successful. Misra and Joshi (1952) and Bhatia (1955*b*) have shown that the tree gets eliminated from its forest on account of intensive biotic disturbances. Protection against these on base rich soil can make its growth successful in plantations outside its territory.

Sal (*Shorea robusta*) unlike teak is a gregarious species. Its forests are extensively distributed in Jabalpur, Balaghat, Mandla, Bilaspur, Sarguja, Jashpur, Bastar, parts of Raipur and Pachmarhi, which roughly lie in 50 - 75 inches rainfall belt of the State (cf. Puri 1953). Both Puri (1951) and Khan (1953 and 53*a*) report its occurrence on different types of rock and soil poor in calcium, giving on the whole an acidic reaction between pH 5·4—7·0. Sathe (1951), on the other hand, reported no correlation between calcium content of rocks and sal growth. It may be pertinent to examine the exchangeable calcium content of the soils as has been done for teak. Puri and Sharma (1951) are of the opinion that sal regeneration suffers on soils rich in organic matter. This is in conformity of earlier observations in U. P. that occasional fire promotes regeneration. Khan's (1953) finding that annual fires and removal of ground vegetation increase soil acidity, is interesting in this context. Hewetson (1952, 53) has discussed the ecological position of sal in the forests. Jain and Pandeya (1957) have recently hit upon the physiologico-ecological behaviour of sal, and their results are awaited with interest.

A number of other forest trees have also been studied in recent years. The most important study is that of Sharma (1955) on *Boswellia ser ata* Roxb. The tree is in great demand for paper pulp, but its regeneration in the forests is extremely poor. It is a component of tropical dry deciduous forests of the seral stages in Madhya Pradesh. According to Sharma (1955), the plant

is generally restricted to immature, eroded, shallow, sandy or gravelly loam derived from sandstones. Moderate quantities of soil organic matter favour its growth. An analysis of the plant showed a higher uptake of calcium at higher pH and a fall in foliar nitrogen with increasing soil nitrogen. The tree is drought resistant and preceeding drought increases seed regeneration in the succeeding rains. The reproductive capacity is very much lessened by insect attacks and by rodents eating up the seeds. 88% of the seeds on the forest floor of Shahgarh were damaged by chalcids and rodents. In other forests 95% of the seeds were found destroyed within one month of their dispersal. Only 3—4 seedlings per acre were found to be established. In Khandwa 100% mortality of seedlings, due to inter-specific competition and browsing, was recorded. Saplings suffer from ravages of pigs eating up the fleshy roots and termites working up through the roots to the pith of the stem. Porcupines are destructive to the adult trees. Culture experiments led Sharma to recommend propagation of the tree by root cuttings and application of moderate dose of organic manure to a loam soil for obtaining optimum yield.

Khan (1952) studied the distribution of *Lannea grandis* Engler in South Raipur division. His findings indicate that the plant prefers a moderately deep soil with a fair amount of humus and a little moisture. Moderate shade at early stage, full light at the middle age and protection from hot wind at later stage of the growth are required by the tree.

Chaurey (1953) studied the reproductive capacity of six dominant trees of Patharia forests. *Anogeissus latifolia* produced the maximum number of seeds but very few of them germinated. Recently Joshi and Pandeya (1957) have undertaken autecological study of this plant, and they report only 2% germination under most favourable conditions. An explanation of the wide distribution of this plant is awaited from their study. Chaurey (1953) further shows that *Tectona grandis* has the maximum reproductive capacity followed by *Butea monosperma* and *Diospyros melanoxylon*. Although seed output was high in *Terminalia tomentosa* and *Diospyros melanoxylon*, germination in both was poor. Regeneration capacity by vegetative means, however, was found to be very high in *Diospyros melanoxylon* and *Lagerstroemia parviflora*. Jesani (1953) studied the soil conditions corresponding to the trees studied by Chaurey, and showed that among these *Butea monosperma* possessed the maximum amplitude for pH, base deficiency, organic, moisture and carbonate contents.

The working plans prepared by the forest officers for different divisions, from time to time, constitute a valuable body of reference for forest ecology. However, the main objective in writing them is to prescribe a suitable management of the forest for better and continuous yield, and as such the data given in them is of limited value. But, in recent years, perhaps, these are the only accounts of forests in the old Madhya Bharat State except for Pillai's (1954) description of the forests of Bhopal and Saigal's (1954) for those of Vindhya Pradesh.

Mathanda (1954, 55a) has published the annual report for 1952 of forest research in the State and on the constitution and rate of growth of a tropical moist deciduous forest in south Chanda division. Dutta (1954) has discussed the problems of forestry in the State.

Misra and Joshi (1952) studied the forests of Patharia hill at Sagar. Anthropogenic factors keep on disturbing the equilibrium of forest—substratum growth,

A basic type of forest constituting the climatic climax has been postulated as that of *Terminalia—Diospyros—Butea*, from which the edaphic and biotic variants are derived. On account of their seral character, most of the forests are mixed. A scheme of succession beginning with different substrata is given by them. Bhatia (1954) has further elaborated the scheme. Brief descriptions of forests, in relation to soil, are given by Misra (1951, 56) for Ghatera and Amarkantak.

Mixed deciduous forests with some 250—300 species of trees, shrubs and climbers are dominant over the major part of the State except where sal is present, according to Hewetson (1955). Local floristic variations are considered by him as due to soil, historical and chance factors. From the working plans of reserved forests distributed over twenty divisions he recognised three main groups—as those on trap with teak, those in the central area without teak or sal, and those of the eastern area with sal. According to his analysis, *Anogeissus—Terminalia* mixed deciduous forest is the climax type which has been replaced by sal forests in moisture areas. However, it should be remembered that *Anogeissus* spp. thrive on eroded land, and although such area is most common in the State, a climax type must be tested by the stability and maturity of the substratum (cf. Misra and Puri 1957), and it is this consideration which led Misra and Joshi (1952) to formulate the climax of *Terminalia—Diospyros—Butea*, as based upon an intensive study of the Patharia forests.

3. ECOLOGY OF GRASSES AND GRASSLANDS

Grasslands in the State have come up in areas denuded of forests or as fillings in open forest. Since the grasses are shallow rooted, they are good indicators of soil conditions. The economic importance of the grasses needs no special emphasis. Rai (1952) has written about the management and improvement of forest grazing in the State.

S. D. N. Tiwari (1954-55) has published a series of papers on the grass flora with notes on their phenology and habitat. Balapure (1954) studied the reproductive capacity of six common grasses at Sagar and found that the same was very high in *Apluda aristata* Lin. and *Cymbopogon martini* Beauv. He further observed that moderate grazing and fire promoted seed output in the grasses.

Pandeya (1953) critically examined the species of *Dichanthium* and studied their distribution in relation to ecological factors. The study was supported by culture experiments. It revealed that there were really only two species, viz., *D. annulatum* Stapf and *D. caricosum* A. camus, which produced a number of habitat forms in response to drought and grazing. Besides *Dichanthium,* he (1953) studied the autecology of *Bothriochlloa pertusa, Themeda caudata* and *Iseilema anthephoroides.* The last named species has been studied by S. D. N. Tiwari (1956) also. *Dichanthium* and *Bothriochloa* have a very wide ecological amplitude. *Themeda* and *Iseilema* succumb to grazing and erosion. They are found under protection on mature soil as dominant grasses. D. K. Tiwari (1955) has given autecological notes on *Andropogon pumilus* Roxb., *Heteropogon contortus* Roem and Schult., *Cymbopogon martini* Stapf and *Chrysopogon montanus* Trin. Further work on ecology of grasses is continuing at Sagar.

Trivedi (1957) is pursuing the distribution of grasses according to rock formations. Misra (1956) has described the dense rolling monsoon grasslands studded with bushes. A detailed ecological study of these grasslands is found in the writings of Pandeya (1952, 53, 55) and D. K. Tiwari (1952, 54, 55). Pandeya's work confined mostly to Sagar, includes a comprehensive study of the soil, climatic and biotic

factors and succession in the grasslands. In this work he has evolved appropriate techniques for evaluation of ecological attributes of the plants. Biological spectra of the grasslands have been successfully interpreted by Pandeya (1953) as reflecting the intensity of grazing. D. K. Tiwari (1955), besides making ecological and phytosociological survey, has concentrated upon the bioecology of the grasslands of Madhya Pradesh. The latter study revealed a wide flux in the floristics representing bioseral associations The effect of three major biological processes, viz. response, reaction and coaction have been examined in five associations of grasslands. The associations according to him are (1) *Themeda—Cymbopogon* on low hillocks and in valleys of Deccan trap, (2) *Apluda—Chrysopogon* in partly shaded areas of South Madhya Pradesh, (3) *Iseilema—Heteropogon* on grazed hill tops and slopes, (4) *Dichanthium—Bothriochloa* on deeper soil in valleys and on foot of hills exposed to moderate grazing, mowing and fire, and (5) *Andropogon—Eragrostis* on marginal and wastelands exposed to overgrazing and erosion. Several useful informations of economic importance are found in Tiwari's work.

4. SPECIALISED HABITATS

Mall (1955) has made a critical study of the seasonal vegetation which occupies drying beds of pools. Such substrata remain inundated with water during the monsoon season, hence the pedological processes under alternating subaqueous and dry conditions produce a clayey soil with high base status. The plant propagules are also processed under the peculiar conditions, and hence the habitat acquires a highly specialised plant community. The study has shown that prostrate and mat forming habit is common among the plants. They bear strong tap root system, which, in many cases, becomes fleshy. The plants are exceptionally hairy with a high stomatal frequency in the leaves. The behaviour of seed germination in most cases explains the incidence of these species in such localities.

Sarma (1952) studied the ecology of dry stream beds of Sagar. The substrata in such habitats are extremely unstable on account of intense erosion and deposition during the monsoon season. The vegetation in most cases was found to be xerophytic as the coarse medium cannot hold moisture after the rains.

The vegetation of Biarma river near Ghatera is described by Misra (1951) with details of soil conditions. The shallow and rapidly running streams had a strong growth of *Rhabdia lycioides* and the sandy pools along the shore contained *Crinum defixum*. Muddy pools have characteristic aquatic flora of ponds. The bank of the river when not much disturbed gets a cover of low forest with *Eugenia heyneana* fringing the water. Misra (1955) has further given a list of plant indicators for erosion, deposition, silting, lime rich soil, and various conditions of water in ponds.

Aquatic and marsh vegetation types together with their habitat have been considered by Misra (1956), M. P. Srivastava (1956) and J. P. Srivastava (1949). The latter two authors have given interesting data on penetration of light and pH of water and physical and chemical characters of mud in relation to depth zonation of the aquatic flora in Sagar lake. Further work is progressing in this direction.

5. AUTECOLOGY OF ANNUALS AND HERBACEOUS PERENNIALS

A correct assessment of the ecological niches of any plant can be gained by a study of its autecology. Most of such studies in India were confined to trees, and these necessarily could not be better than compilation of notes on certain phases

of the life cycle, as no individual worker can possibly gather experimental and cultural data for the whole life cycle of an organism living longer than himself. Hence the autecology of a number of herbaceous species was pursued by some workers at Sagar. It has thrown a flood of light on some fundamental problems of ecology.

Bakshi (1949, 51, 52, 52a) in a series of papers has shown that *Anisochilus eriocephalus* Benth. growing on house tops roofed with country tiles has a very high seed output and seed dispersal. But poor germination, 92·3% mortality among the seedlings, a high susceptibility to interspecific competition and waterlogging with poor aeration have driven the species to the peculiar habitat. Furthermore, he has shown that *A. carnosus* Wall. is an ecotype of *A eriocephalus* Benth. M. P. Shrivastava (1952) has discussed among other things low sociability, absence from forests and endemism of *Heylandia latebrosa*. Sharma (1953) showed that *Sida acuta* Burm. is eliminated by *Cassia tora* and other plants from what would appear from culture experiments as its natural habitat, to open areas. Trivedi (1955) explained the gregariousness of *Sesbania bispinosa* on the basis of habitat factors and immobility of seeds which are produced in large number.

Das (1955), Koul (1955), and Shams (1955) worked on the autecology of *Xanthium strumarium* Lin. The root—soil relations, interspecific competition and photoperiodic behaviour of the plant were shown as relevant points in its distribution and behaviour. Mall (1956) studied germination behaviour and variations in osmotic concentration of the plant in relation to soil moisture in *Chrozophora roitleri* A. Juss. Mall (1955) also studied the autecology of *Cassia tora* and *C. obtusifolia* which show co-extensive and gregarious distribution. No ecological isolation was found between the pair of species. Mall's (1955) interesting observations on the species of dry beds of pools have already been indicated. The Sagar school has also studied the ecology of *Tridax procumbens, Achyranthes aspera, Polygonum plebejum, Trichodesma indicum, T. amplexicaule* and *Gleome chelidoni* bringing out a series of facts of ecological interest.

6. SOIL DEVELOPMENT

Soil – the medium of plant growth, and vegetation go hand in hand, and hence the Sagar school laid emphasis on pedology. Upadhyaya (1955) worked out the effects of plant cover on soil development. He showed that annual litter production in our forests is much higher and in the grasslands much lower as compared to those of temperate regions and that the organic increment in forests is received in March – April with maximum rate of decomposition during the monsoon period and in grassland soils it was received and decomposed in October – November. The relative rates of decomposition of dry leaves of different species was studied in relation to soil conditions and nutrient circulation. Difference in forest and grassland soils have been accordingly explained.

The red and the black soils of the State have been a problem to most pedologists. The processes of leaching under alkaline and acid conditions and its effect on the SiO_2/R_2O_3 ratio has been worked out by Bhatia (1954) and Upadhyaya (1955). Pandeya (1952) compared the black or 'regur' soil with the 'chernozem' of Russian pedologists. But Sant (1953) has experimentally demonstrated that black colour arises due to association of humus with carbonates in the soil under intermittent anaerobic and aerobic conditions. This may explain the origin of black soils in valleys and on flats as against the leached red soils occurring on tops

of hills or extremely leached areas. Misra (1955) has discused some important aspects of the natural soils of Sagar. From Upadhyaya's (1955) work it may further appear that slow decomposing litter under *Butea monosperma, Madhuca latifolia* and grasses would be helpful in production of the black soil. In fact more work of this type is needed to resolve the complex dynamics existing between soil development and plant cover under our climatic conditions. Saksena's (1955) work on the ecological factors, governing the distribution of soil microfungi in some forest soils at Sagar, indicates a close parallelism between the development of the fungi, the soil and the plant cover.

7. CONCLUSION

In this brief review I have presented the various aspects of plant ecology in which research has progressed in the State. There is need for detailed physiologico —ecological studies of forest trees and other species. For further work it is necessary for us to realise that the plant has a very potent biological surrounding to which it strongly reacts. This we very often forget in our study of the physical environment. Historical factors will also have to be taken into account in any programme of study.

It is further clear that Madhya Pradesh has not lagged behind in producing good work in ecology. It is a monument of fine co-operation that exists between University men and forest officers. The wild surroundings of this State inspire the ecologist to probe into nature deeply and extensively. This interest, I hope, will be sustained as much for the sake of knowledge as for exploiting the wealth of the vegetation.

I thank you for a patient hearing.

8. BIBLIOGRAPHY

Bakshi, T. S. 1951. Autecology of *Anisochilus eriocephalus* Benth. *Bull. bot. Soc. Univ. Saugar*, 1, : 5-7.

——————— 1952. The Autecology of *Anisochilus eriocephalus* Benth. *J. Indian bot. Soc.* 31:269-80

——————— 1952a. The effect of a preliminary period of darkness on the percent germination of the seeds of *Anisochilus eriocephalus* Benth *Curr. Sci.* 21:108.

Balapure, K. M. 1954. Reproductive capacity of six common grass species. *Bull. bot. Soc. Univ. Saugar*, 6:16-18.

Bhatia, K. K. 1954. Factors in the distribution of teak (*Tectona grandis* Linn. f.) and a study of teak forests in Madhya Pradesh. *Ph D. Thesis, Saugar. Univ.*

——————— 1955. Teak bearing forests of Madhya Pradesh. *Symp. Indian bot. Soc.* Baroda.

——————— 1955a. Foliar calcium of teak. *J. Ind. bot. Soc.*, 34:227.

——————— 1955b. Factors in the distribution of teak in Madhya Pradesh. *J. Ind bot. Soc.* 34:459-90.

——————— 1956. Contribution to the ecology of teak (*Tectona grandis* Linn.f.) in Madhya Pradesh. *J. Ind. Bot. Soc.*, 35:357-364.

Brandis, D. 1921. *Indian Trees.*

Champion, H. G. 1936. A preliminary survey of the forest types of India and Burma. *Ind. For. Rec.*, (New Series) 1:1-286.

Chaurey, S. L. 1933. A study of the reproductive capacity of six dominant forest trees. *M.Sc. Thesis, Saugar Univ.*

Das, M. G. Jagadisa 1955. An autecological study of *Xanthium strumarium* Linn. with special reference to its distribution in relation to reproductive capacity and biotic factors. *M.Sc. Thesis, Saugar Univ.*

Dutta, R. N. 1954. Forestry in M. P. *Ind. For.* 80 :

Harlow, C. M. 1937. Forests in the Central Provinces. *Ind. For.* 63:1-144.

Hewetson, C. E. 1941. Observation on the ecology of *Tectona grandis* in the Central Provinces. *Ind. For.*, 67:617-29.

——————— 1950. Seventy-five years of fire protection in the Tropics. *Emp. For. Rev.*, 29:4.

——————— 1951. Ecology of *Tectona grandis. Madras For. Coll.* Mag., 27:101-08.

——————— 1952. Sal in South Bastar Division, M. P. *Ind. For.* 78 :

——————— 1953. A discussion on the ecological position of Sal in Central India. *Ind. For.* 79 :

——————— 1954. Fires and their ecological effects in M. P. *Ind. For.* 80 :

——————— 1955. A discussion on the climatic climax community in Central India. *Symp. Ind. bot. Soc.*, Baroda.

Jain, K. N. & Pandeya, S. C. 1957. Ecology of Sal (*Shorea robusta* Gaertn.) in Madhya Pradesh. *Unpublished.*

Jesani, S. C. 1953. Edaphic factors in the distribution of some forest trees of Sagar. *M.Sc. Thesis, Saugar Univ.*

Joshi, S. R. & Pandeya, S. C. 1957. Autecology of *Anogeissus latifolia* wall. *Unpublished.*

Khan, M. A. W. 1952. *Lannea grandis* Engler. *Ind. For.* 78:311-314.

——————— 1953. Effects of geological formations on the distribution of Sal. *Ind. For.* 79 :

——————— 1953a. South Raipur Sal forest and its ecological study with reference to its management. *Ind. For.* 79 :

Koul, V. N. 1955. Autecological studies of *Xanthium strumarium* Linn. soil pH, NO_3, CO_3, exchangeable calcium and photoperiod in relation to growth of *Xanthium strumarium* Linn. *M.Sc. Thesis, Saugar Univ.*

Kulkarni, D. H. 1951. Distribution of teak (*Tectona grandis*) on the Northern Slopes of Satpuras with special reference to geology. *Proc. 8th Silv. Confr.*, Dehra Dun.

——————— 1953. Distribution of teak (*Tectona grandis*) on the Northern Slopes of Satpura Hills. *Bull. bot. Soc. Saugar Univ.* 5:2-5.

Lamba, G. S. 1945. Teak regeneration in the Central Provinces. *Ind. For.* 71:346.

Laurie, M. V. 1931. Teak and its lime requirements. *Ind. For.* 57:377-81.

and Griffith, A. L. 1941. The problem of pure teak plantation. *Ind. For. Rec.* 5:1-121.

Mall, L. P. 1955. Ecology of drying ponds and some common weeds. *Ph.D. Thesis Saugar Univ.*

——————— 1956. Some aspects of the autecology of *Chrozophora rottleri* A. Juss. *Bull. bot. Soc., Saugar Univ.* 8:13-24.

Mathanda, G. S. 1954. Annual report of forest research in Madhya Pradesh (1952). *Ind. For.* 80 :

——————— 1955. The constitution and rate of growth of a tropical moist deciduous forest in South Chanda Division, Madhya Pradesh. *Ind. For.* 81.

Mc. Donald, T.	1940. Bori reserves, 1859-1940. *Ind. For.* 66:529-43.
Misra, R.	1951. The vegetation of Ghatera (M. P.), *Bull. bot. Soc. Saugar Univ.* 3: 12-18.0
———and Joshi, N. K.	1952. The forest complex of Patharia hills. *J. Ind. bot. Soc.* 31:154-170.
Misra, R.	1955. The vegetation of Sagar. *Symp. Ind. bot. Soc.* Baroda.
———	1955a. Natural soils of Sagar. *J. Saugar Univ.* 1 (New series) : Part II-1-4.
———	1955b. Progress of plant ecological studies in India. *Bull. bot. Soc., Saugar Univ.* 7:90-101.
———	1955c. Some plant indicators of Sagar (M. P.). *Symp. bot. section : applied ecology—42nd Ind. Science Congress,* Baroda.
Misra, R.	1956. The study of tropical vegetation in Madhya Pradesh and the Gangetic valley. *Symp. on the study of Tropical vegetation.* UNESCO, Kandy, Ceylon.
————————	1956*a*. The vegetation of Amarkantak. *Bull. bot. Soc. Saugar Univ.* 8: 1—2.
———and Puri, G. S.	1957. *Indian Manual of Plant ecology,* pp. 356, The English Book Depot. Poona.
Mobbs, E. C.	1941. The early history of Indian forests. *Ind. For.* 67: 231-242.
Pandeya, S. C.	1949. An ecological study of the vegetation of Saugar University grounds. *M. Sc. Thesis, Saugar Univ.*
———————and Sharma, J. K. V.	1950. The biological spectrum of the flora of Makronia plateau. *Bull. bot. Soc. Saugar Univ.* 2: 2-6.
————————	1952. Grasslands of Saugar, Madhya Pradesh. *Ind. For.* 78: 638-54.
————————	1952*a*. Succession in grasslands of Saugar, Madhya Pradesh. *J. Saugar Univ.* 1: 111-127.
————————	1953. Ecological studies of grasslands of Sagar. *Ph. D. Thesis, Saugar Univ.*
————————	1953*a*. Studies in the morphology and ecology of three species of *Dichanthium* willemet. *J. Ind. bot. Soc.* 32: 86-100.
Pillai, K. R. N.	1954. The forest of Bhopal State. *Ind. For.* 80 : 774-78.
Puri, G. S.	1951. Advances in the ecology of teak (*Tectona grandis*) in India. *Proc. 8th. Silv. Confr.*, Dehra Dun.
———and Sharma, B. K.	1951. The ecology of some Sal (*Shorea rabusta* Gaertn.) forests of Madhya Pradesh. *Proc. 8th Silv. Confr.*, Dehra Dun.
————————	1953. Problems in the ecology of Sal (*Shorea robusta*) in Madhya Pradesh. *Bull. bot. Soc., Saugar Univ.* 5: 24-31.
Rai, Lakhpat.	1952. Management and improvement of forest graging in Madhya Pradesh. *Ind For.* 78.
Saigal, D. D.	1954. Forests of Vindhya Pradesh. *Ind For.* 80: 861-65.
Saksena S. B.	1955. Ecological factors governing the distribution of soil microfungi in some forest soils of Sagar. *J. Ind. bot. Soc.* 34: 262-298.
Sarma, V. S.	1952. Ecological study of the vegetation of stream beds of Sagar. *M. Sc. Theis, Saugar Univ.*
Sathe, P. G.	1951. The role of geology in the distribution of Sal and other plant communities in some forests of Madhya Pradesh. *Proc. 8th Silv. Confr.*, Dehra Dun.
Shams, A. H.	1955. Autecological studies of *Xanthium strumarium* Linn. Root development in relation to some edaphic conditions. *M. Sc. Thesis, Saugar Univ.*

Sharma, V. B. 1953. Autecology of Sida acuta Berm. *M. Sc. Thesis, Sagar Univ.*

Sharma, V. B. 1955. An autecological study of *Boswellia serrata* Roxb. *Ph. D. Thesis, Sagar Univ.*

Shrivastava, J. P. 1949. An ecological study of the manophytic vegetation of Sagar lake. *M. Sc. Thesis, Sagar Univ.*

Shrivastava, M. P. 1952. Autecology of *Heylandia latebrosa Dc. M. Sc. Thesis, Sagar Univ.*

———————— 1956. Hydrophytes of Sagar lake. *Bull. bot. Soc., Sagar Univ.* 8:34-36.

Takle, C. G. and Majumdar. 1956. Increasing growth and natural regeneration of teak. *Ind. For.* 82:

Tiwari, D. K. 1954. An ecological survey of grasslands of Sagar. *J. Sagar Univ.* 1 *Part* II: 1-19.

———————— 1955. A study of the bioecology of grasslands of Madhya Pradesh (India). *Ph. D. Thesis, Sagar Univ.*

Tiwari, S. D. N. 1954. Teak the Intruder. *Ind. For.* 80:

———————— 1954*a*. Grasses of Madhya Pradesh. *Ind. For.* 80.

———————— 1955. Grasses of Madhya Pradesh. *Ind. For.* 81.

———————— 1956. *Iseilema anthephoroides. Ind. For.* 82.

Trivedi, T. S. 1955. Autecology of *sesbania bispinosa* Fawcett et Rendle with special reference to its distribution. *Bull. bot. Soc. Univ. Sagar.* 7: 55-60.

Upadhyaya, S. D. 1953. Distribution of some plant communities in relation to soil. *M. Sc. Thesis, Sagar Univ.*

———————— 1955. Soil formation in relation to plant cover. *Ph. D. Thesis, Sagar Univ.*

Vahid, S. A. 1927. An attempt to correlate on the geology and forest types of North Chanda Division, C. P. *Ind. For.* 53: 576-82.

PHYSICAL SCIENCES SECTION
ABSTRACTS OF PAPERS

INFLUENCE OF MOLYBDENUM, VANADIUM, BORON AND ZINC ON THE CHANGES OF CARBON, NITROGEN AND THE C/N RATIO IN THE INCUBATION OF WHEAT STRAW

By N. R. DHAR *and* A. C. GAUR

Sheila Dhar Institute of Soil Science, University of Allahabad

It is observed that molybdenum, vanadium, boron and zinc, when used in the incubation of wheat straw along with rock phosphates or basic slag, help in the oxidation of the organic matter. The addition of these trace elements increases the nitrogen fixation. Molybdenum is the best.

The C/N ratio in presence of molybdenum, vanadium, boron and zinc is smaller than with and without phosphates.

FERRIC SUCCINATE GELS

A POTENTIOMETRIC AND CONDUCTOMETRIC STUDY

By S. K. BOSE *and* S. P. MUSHRAN

Department of Chemistry, University of Allahabad

Ferric chloride reacts with sodium succinate to produce normal ferric succinate. It is observed that by choosing suitable concentrations of the reactants stable and transparent gels of ferric succinate may be obtained. The methods involving conductometric and potentiometric measurements are adopted to find out the nature of the precipitate that separates out. It is noted that by the stepwise addition of sodium succinate to ferric chloride no precipitate but a colloidal solution is produced. The hydrous oxide, hydrogen succinate and normal succinate of the metal are formed, and near about the equivalent point the normal succinate predominates. For the purpose of gelation a definite range of the hydroxonium ion concentration is of the interacting mixtures is important. At a lower pH the precipitate remains in colloidal state and at a higher one a thick gelatinous precipitate appears instead of a gel. Near the equivalent point gels obtained are most transparent and firm in texture. They are slightly acidic in nature. An accurate method of the determination of the gelling time is also described.

STUDIES IN PRECIPITATION AND SOLUBILITY OF SPARINGLY SOLUBLE PHOSPHATES

By N. R. DHAR *and* K. M. VERMA

Sheila Dhar Institute of Soil Science, University of Allahabad

(1) On neutralizing aqueous solutions of orthophosphoric acid with solid $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$ and ZnO, it has been observed that the amounts of P_2O_5 and basic oxides remaining in solution are in the following order,

$$Sr > Ca > Ba >$$

This observation is supported by the solubility determinations with these phosphates, which show that strontium phosphate is more soluble than calcium; or barium phosphate.

(2) In the neutralization of strontium hydroxide and phosphoric acid in the molar ratio 1:1, no solid phosphates are found with 4 M to 0·04 M solutions; with other molar ratios, there is always the formation of a solid phosphate, the disalt when the ratio is 2:1 and a mixture of the di-and trisalt when the ratio is 3:1 (more trisalt is produced than the disalt).

(3) In the case of calcium hydroxide there is the formation of the solid when the molar concentrations are 4 M, 2M, M, 0·5 M, 0·2 M with the ratio 1:1 but not when the concentrations are 0·1 M and 0·04 M.

In the ratio of 1:1, the disalt separates out and in the ratio 2:1, the disalt is formed and finally in the 3:1, a mixture of disalt and trisalt, nearly half and half, separates out.

(4) In the case of barium hydroxide with 1:1 molar ratio, there is always a precipitation and a disalt is formed. With 2:1, there is precipitation with the formation of the disalt. With 3:1, a mixture of di and tri salts are formed but the mixture contains greater amounts of tri than the di salts.

(5) The formation of the trisalts with the 3:1 ratio is in the following order :

$$Ba > Sr > Ca$$

With ZnO there is always the formation of the trisalt in all the ratios and hence the solution always is much richer in phosphoric acid than zinc oxide.

(6) For the commercial production of $CaHPO_4$ and $CaHPO_4\ 2H_2O$, which are largely utilized in animal feeding and fertilizer, best results are obtained by mixing lime and phosphoric acid in the molar ratio 2:1.

CHANGES IN THE POROSITY, STICKY-POINT, MOISTURE CONTENT AND EXCHANGEABLE CALCIUM IN DUMAT SOIL OF AGRA DISTRICT BY HUMIFYING THE LEGUMIOUS WEEDS (1) WILD INDIGO (TEPHROSIA PURPUREA) AND (2) JWASA (ALHAGI CAMELGRUM).

By B. R. NAGAR *and* ABANI K. BHATTACHARYA

Department of Chemistry, Agra College, Agra

Two leguminous weeds—(1) Jwasa (Alhagi camelorum) and (2) Wild Indigo (Tephrosia purpurea) were humified (for sixteen weeks) in the Dumat soil of Agra district and the changes in the porosity, sticky point, moisture content and exchangeable calcium were studied at various intervals of time.

It has been observed that on the humification of afore mentioned weeds the values of sticky point, porosity and exchangeable calcium were greater in the humified samples than in the untreated soils. The moisture content was found highest during the first week of humification and then there was a tendency of decrease in moisture level. The moisture content of the humified soil samples was much higher than that of original untreated soils.

SOME OBSERVATIONS REGARDING THE RELATION BETWEEN THE SPECIFIC HEAT AND THE THERMAL CONDUCTIVITY OF METALS (SOLIDS) AT ORDINARY TEMPERATURE

By P. C. PAL

Government Engineering College, Jabalpur

Depending on the practical values, the relation has been obtained purely from a graphical method by arranging the metals into sub-groups according the periodic classification. The general equation for a particular sub-group is found to be $S = aK^2 + bK + C$. The curves of sub-groups *a* are concave *upwards* and those of sub-groups *b* are concave *downwards*. There is a distinct and *regular* variation of the constants a, b and c with sub-groups *a* or *b* and so also the axes of the different curves. Finally, Dulong and Petit's law has been modified from the idea of the atom structure and has been applied to obtain the equation $Z \times K^2 =$ a constant, for a particular sub-group which follows the practical values. The new formula has been applied to find out the thermal conductivity of metals whose values were not available during the work. The actual values of the thermal conductivity of some of these metals were obtained later on and were found to agree very well with the predicted values.

KINETICS AND MECHANISM OF SILVER CATALYZED OXIDATION OF BIVALENT MANGANESE BY THE PERSULPHATE

By YUGUL KISHORE GUPTA *and* SATYESHWAR GHOSH

Department of Chemistry, University of Allahabad

Oxidation of bivalent manganese by the persulphate itself is very slow, which becomes fast in the presence of silver ion. In the silver ion catalyzed reaction, the product of oxidation is trivalent manganese which immediately disproportionates in manganese dioxide and bipositive manganese. The kinetics were followed by running the reaction mixture in the excess of oxalic acid and estimating the unused oxalic acid with the permanganate.

The reaction was found to be unimolecular with respect to the persulphate and zeromolecular with respect to the manganous ion. The salt effect is negative and exponential. The energy of activation and entropy have been calculated. There seems to be no influence on the reaction rate for the hydrogen ion concentration within the range investigated except that the reaction mixture becomes slightly red due to the stabilization of the trivalent manganese in the acid medium. A mechanism has been suggested in consistent with the observed facts.

THE CHARACTERISTIC ROOTS OF THE PRODUCT OF TWO MATRICES

By N. A. KHAN

Department of Mathematics, Muslim University, Aligarh

The following theorem gives the upper and lower bounds for the real and imaginary parts of the characteristic roots of AB, the product of two matrices A and B. In the sequel, $H_1=(A+A^*)/2$, $K_1=(A-A^*)/2i$, $H_2=(B+B^*)/2$ and $K_2=(B-B^*)/2i$, and c(A) denotes a characteristic root of A.

Theorem. *Let A and B be two commuting n-square matrices, such that the Hermitian matrices* H_1, K_1, and H_2 *are at least positive semi-definite. Then*

$$c_m(H_1)c_m(H_2) - c_M(K_1)c_M(K_2) \leqslant \text{Re } c(AB)$$
$$\leqslant c_M(H_1)c_M(H_2) - c_m(K_1)c_m(K_2),$$
$$\text{and } c_m(H_1)c_m(K_2) + c_m(K_1)c_m(H_2) \leqslant \text{Im } c(AB)$$
$$\leqslant c_M(H_1)c_M(K_2) + c_M(K_1)c_M(H_2),$$

where c_M *and* c_m *stand respectively for the greatest and least characteristic roots.*

The cases, when H_1, K_1, H_2, K_2 are negative semidefinite, indefinite also have been considered.

If we put $B=I$ in these results we obtain the results of Hirsch (Acta Mathematica, vol. 25(1902)) and Bromwich (Acta Mathematica, vol. 30 (1906)) as particular cases.

CHANGES IN THE pH AND CONDUCTIVITY IN DUMAT SOIL OF AGRA DISTRICT BY HUMIFYING THE LEGUMINOUS WEEDS (1) WILD INDIGO (TEPHROSIA PURPUREA) AND (2) JWASA (ALHAGI CAMELORUM)

By B. R. NAGAR *and* ABANI K. BHATTACHARYA

Department of Chemistry, Agra College, Agra

Two leguminous weed— (1) Jwasa (Alhagi camelorum) and (2) Wild Indigo (Tephrosia purpurea) were humified (for sixteen weeks) in the Dumat Soil of Agra district and the changes in pH and conductivity were studied at various intervals of time.

It has been observed that when there is a fall in pH, the conductivity rises in most cases and the variations are periodic. After sixteen weeks of humification there is an increase in pH and the conductivity is much greater, in the humified soil sample than in the original and untreated soils.

STUDIES IN FAT PRODUCTION BY ADDING SODIUM SALTS OF ALIPHATIC ORGANIC ACIDS TO EDIBLE YEASTS

By N. R. DHAR *and* P. S. B. NAIDU

Sheila Dhar Institute of Soil Science, University of Allahabad

On adding sodium acetate in increasing amounts to 100 c.c. glucose medium impregnated with one drop of Dhar yeast suspensions and containing the following substances :—

Glucose	...	...	5 gms.
Potassium sulphate	...	...	0·4 gm.
Ammonium sulphate	...	...	0·4 gm.

Sodium dihydrogen phosphate...	...	0·2 gm.
Magnesium sulphate	...	... 0·05 gm.
Calcium chloride	...	... 0·01 gm.
Zinc sulphate	...	... 0·02 gm.
Copper sulphate	...	... 0·01 gm.

It was observed that the Dhar yeast obtained contains greater amount of fat than the control set without the acetate. These experimental results show that acetates are converted into fats in the yeast cells.

KINETICS AND MECHANISM OF SILVER CATALYZED OXIDATION OF OXALATE BY THE PERSULPHATE

By YUGUL KISHORE GUPTA *and* SATYESHWAR GHOSH

Department of Chemistry, University of Allahabad

This reaction, both catalyzed and uncatalyzed, has been studied previously by many workers and no reproducible results could be obtained, nor the order of the reaction could be established with certainty. However, the nature of the results was in the expected order. We have studied this reaction in presence of hydrogen and silver ions, The kinetics were followed by estimating the persulphate iodometrically by the method of Szabo, Csanyi and Galibra (Z. anal. Chem., **135**, 269-75, 1952.)

The order with respect to the persulphate is unity. The oxalate concentration has little effect on the reaction rate. No salt effect was observed. The reaction is greatly susceptible to the specific effect of the ions. Nitrate, Na, K, ammonium, Mg and Mn ion greatly inhibit the reaction whereas hydrogen and sulphate ions act as good accelerators. A mechanism has been suggested in cosistent with the observed facts.

ON SYMBOLIC CALCULUS OF TWO VARIABLES

By C. B. L. VARMA

Department of Mathematics, Mahakoshal Mahavidyalaya, Jabalpur

The following theorems are proved :—

Theorem I

$$\text{If} \quad f(p) \doteqdot h(x)$$

$$\text{and} \quad \frac{1}{p^{2\nu-1}} h(p^2) \doteqdot g(x)$$

$$\text{Then} \quad f\left(\frac{p}{q}\right) \doteqdot H\left(\frac{x}{y}\right)$$

$$\text{where} \quad H\left(\frac{x}{y}\right) = \frac{\sqrt{2}}{\sqrt{\pi}} \frac{1}{2^{\nu}} \left(\frac{x}{y}\right)^{\nu} \int_0^{\infty} e^{-\frac{s^2 x}{8y}} D_{2\nu-1}\left(\sqrt{\frac{s^2 x}{2y}}\right) g(s)\,ds, \quad [\nu > -1]$$

Theorem II

If $f(x) \doteqdot h(p)$

and $p^{\nu} h(\sqrt{p}) \doteqdot H(x)$

Then $H\left(\frac{y}{x}\right) \doteqdot F\left(\frac{q}{p}\right)$

where $$F\left(\frac{q}{p}\right)=\frac{\Gamma(2\nu+2)}{2\nu}\left(\frac{q}{p}\right)^{\nu}\int_{0}^{\infty} e^{\frac{s^2q}{8p}} D_{-2\nu-2}\left(\sqrt{\frac{p^2q}{2p}}\right) f(s)\,ds \qquad [\nu > -\tfrac{3}{2}]$$

The Theorems have been illustrated by suitable examples.

THE OPTIMUM CONDITIONS FOR THE GELATION OF SILICATES OF IRON AND CHROMIUM

By KANHAIYA LAL YADAVA

Department of Chemistry, University of Allahabad

Solutions of sodium silicates of 1:3.200 and 1:4.266 soda silica ratios were treated with varying amounts of chlorides of iron and chromium and were allowed to gelate. Limiting ranges of pH values of the mixtures gelating in two hours were plotted against the percentage concentration of silica. It was found that pH plays an important role in the gelation of these silicates. Further it has been concluded that the gelation is mainly due to free silicic acid present in the system.

EFFECT OF TEMPERATURE ON GELATION OF SILICATES OF IRON AND CHROMIUM

By KANHAIYA LAL YADAVA

Department of Chemistry, University of Allahabad

Sodium silicate solutions were added to chlorides of iron and chromium. Trans-parent sols were obtaind whose pH values were noted and were allowed to gelate at three different temperatures. Logarithm of gelation time was plotted against reciprocal of absolute temperature and a straight line was obtained. Heat of activation for gelation was calculated. It was approximately 8000 calories varying slightly with pH of the gelling material.

CHEMISTRY OF THE COMPLEX COMPOUNDS OF TITAMIUM AND ZIRCONIUM TETRAHALIDES

By G. S. RAO

Department of Chemistry, University of Saugar

The existing work on the chemistry of the complexes of titanium and zirconium tetrahalides is reviewed. The stabilities of these complexes as derived from the dissociation pressures and the data obtained thereby, and infrared spectroscopic measurements have been discussed.

STUDIES ON THE APPLICATION OF AMMONIUM NITRATE ON HEBISEUS ESCULANTUS (INDIAN BHINDI) WITH AND WITHOUT COAL

By P. N. AWASHTHI *and* A. K. BHATTACHARYA

Department of Chemistry, University of Saugar

The recorded observations on total nitrogen, total carbon, ammonical and nitrate nitrogen show that in every case the loss of nitrogen was more without organic matter *i.e.* when the soil was dressed only with ammonium nitrate. This important observation has been confirmed by actually growing Hibiscus Esculantus in pots under controlled conditions.

Photographs and other measurements of the plant are in full agreement with the above view.

THE INFLUENCE OF TEMPERATURE ON THE VISCOSITY AND OTHER PROPERTIES OF FERRIC ARSENATE SOL

By Y. G. KHER *and* S. N. BANERJI

Department of Chemistry, University of Saugar

The viscosity, specific conductivity and stability of ferric arsenate sol have been studied at different temperatures. It is observed that with the rise in temperature (1) the viscosity goes on decreassing, (2) with a concentrated sol, the viscosity first decreases and then increases, and at a still higher temperature it sets to a gel and (3) with increased purity and concentration there is a continuous increase in viscosity till gel formation occurs. (4) The specific conductivity of the sols goes on increasing and this increase in independent of purity and concentration. (5) The stability of the sol increases. The above results have been explained from the point of view that temperature plays an important role in the formation of a skeleton-like structure in the sols under certain conditions.

THE INFLUENCE OF CHEMICAL CONSTITUTION ON THE ROTATORY POWERS OF CINCHONIDINE SALTS OF BENZOIC-,*O*,*M*, AND *P*-HYDROXY BENZOIC ACIDS

By S. P. BANERJEE

Department of Chemistry, University of Saugar

Cinchonidine salts of benzoic-,*6*,*m*, and *p*-hydroxy benzoic aids have been prepared. The rotatory dispersion of these compounds is found to obey Drude's one term equation. In major case the order of decreasing rotatory power runs parallel to the decreasing order of dielectric constants of the solvents. Effect of position isomerism on their rotatory power has been studied and is found to agree with Frankland's "Lever arm" hypothesis as well as Cohen's rule. The effect of hydroxy group on the rotatory power of this compound has been studied and found to obey Rule's generalisation in some cases.

STUDIES IN CHROMIUM TUNGSTATE SOL

PART I. SURFACE TENSION, VISCOSITY, CONDUCTIVITY AND STABILITY WITH THE PROGRESS OF DIALYSIS

By PREM CHAND *and* S. N. BANERJI

Department of Chemistry, University of Saugar

The Chromium Tungstate sol shows all the characteristics of a lyophilic colloid.

The surface tension of the sol increases with the decrease in adsorption of colloid material at the interface until it approximates to a static value.

Three stages of viscosity changes have been observed: (*a*) an initial decrease followed by (*b*) an exponential increase and then (*c*) an abrupt increase accompanying the process of gelation. From the results of viscosity measurements it has been possible to calculate the values of (fraction of the total volume of particles to that of the whole system) using Einstein's and Simha's equations and the consequence is that the particles are asymmetric, the Brownian Motion causing them to fluctuate from their positions producing an extra resistance to flow.

The general form of the curve in the case of impure sol is dependent upon the nature and the magnitude of the effect produced by the gegeions. At the stages of gelation the changes of conductivity are negligible, for the sol attains pure form.

As is to expected stability which depends upon the electric charges on the surface of the sol particles, decreases continuously with the decrease in stabilising agent until gel is formed.

INFLUENCE OF CALCIUM PHOSPHATE INCORPORATED WITH ENERGY-RICH MATERIALS ON SOIL CONDUCTIVITY AND pH

By S. S. SHARMA *and* A. K. BHATTACHARYA

Department of Chemistry, University of Saugar

The effect of calcium phosphate alone and in combination with organic energy-rich materials-glucose, starch, neem leaves and cowdung-on soil pH and conductivity has been studied. The immediate effect of the addition of various above mentioned substances to the soil is to decrease the soil pH and increase the conductivity. After one month the pH increases and conductivity decreases. Then again the pH begins to decrease and the conductivity increases. In the case of calcium phosphate alone, the conductivity shows regular increase. The final results show that incorporation of calcium phosphate with energy rich materials produces better effect in lowering the pH in alkaline soil than with organic matter alone.

INFLUENCE OF CALCIUM PHOSPHATE INCORPORATED WITH ENERGY-RICH MATERIALS ON NITROGEN FIXATION

By S. S. SHARMA *and* A. K. BHATTACHARYA

Department of Chemistry, University of Saugar

The effect of calcium phosphate alone and in combination with organic energy-rich materials glucose, starch, neem leaves and cowdung on the fixation of atmospheric nitrogen in soil has been studied. From the experimental results it has been concluded that the fixation of atmospheric nitrogen by the addition of organic matter to the soil is greatly enhanced by the presence of calcium phosphate.

FORMATION OF COMPLEX COMPOUNDS BETWEEN CADMIUM HALIDES AND ALKALI HALIDES

PART V—SYSTEM $CdCl_2$—RbCl—H_2O

By K. G. KAIMAL *and* A. K. BHATTACHARYA

Department of Chemistry, University of Saugar

The formation of complex compounds between cadmium chloride and rubidium chloride has been studied by the conductivity, viscosity, freezing point, refractive index and pH methods. The graphs obtained show six breaks at exactly the same points indicating the formation of six complexes, namely, $CdCl_2$. 4RbCl, $CdCl_2$. 2RbCl, 2$CdCl_2$. 3RbCl, $CdCl_2$. RbCl, 3$CdCl_2$. 2RbCl and 2$CdCl_2$. RbCl of which only $CdCl_2$. 4RbCl and $CdCl_2$. RbCl have been reported by earlier workers, the other four being new compounds. The above results have been confirmed by the light absorption method.

FORMATION OF COMPLEX COMPOUNDS BETWEEN CADMIUM HALIDES AND ALKALI HALIDES

PART VI—SYSTEM $CdCl_2$ — CsCl — H_2O

By K. G. KAIMAL *and* A. K. BHATTACHARYA

Department of Chemistry, University of Saugar

The formation of complex compounds between cadmium chloride and caesium chloride has been studied by the conductivity, viscosity, freezing point, refractive index, and pH methods. The graphs obtained show six breaks at exactly the same points indicating the formation of six complexes, namely, $CdCl_2$. 4CsCl, $CdCl_2$. 2CsCl, 2$CdCl_2$. 3CsCl, $CdCl_2$. CsCl, 3$CdCl_2$. 2CsCl and 2$CdCl_2$. CsCl of which only $CdCl_2$. 2CsCl and $CdCl_2$. CsCl have been reported by earlier workers, the other four being new compounds. The above results have been confirmed by the light absorption method.

NOTE ON CONVERGENCE FACTORS

By O. P. VARSHNEY

Department of Mathematics, University of Saugar

We consider a regular Norlund transformation where

$$P_n = p_0 + p_1 + p_2 + \ldots\ldots\ldots + p_m.$$

For any series Σu_n, we form sequence $\{\mu_n u_n\}$ and define

$$\sigma_n = \frac{p_0(\mu_n u_n) + p_1(\mu_{n-1} u_{n-1}) + \ldots + p_n(\mu_0 u_0)}{P_n}$$

Corresponding to a set of p's we set

$$\frac{1}{p_0 + p_1 z + p_2 z^2 + \ldots} \sim a_0 + a_1 z + a_2 z^2 + \ldots\ldots$$

The following theorems have been proved :—

Theorem 1. *If* $\{\lambda_n\}$ *and* $\{\mu_n\}$ *are sequences of positive numbers such that* λ_n *is non-increasing, the necessary and sufficient condition that* $\Sigma \mid \mu_n \varepsilon_n \mid < \infty$, *whenever* $\Sigma \lambda_n \mid \sigma_n \mid < \infty$, *for a regular Norlund transformation for which*

$$\Sigma \mid a_n \mid < \infty$$

is

$$\mid P_n \varepsilon_n \mid = O(\lambda_n \mu_n).$$

Theorem 2. *The necessary and sufficient condition that* $\Sigma \mid \mu_n \varepsilon_n \mid < \infty$ *whenever* $\mid \sigma_n \mid = O(\lambda_n)$, *for a regular Norlund transformation for which* $\Sigma \mid a_n \mid < \infty$ *and* $\{\lambda_n\}$ *and* $\{\mu_n\}$ *are sequence of positive numbers, is*

$$\Sigma \mid P_n \varepsilon_n \mid \frac{\lambda_n}{\mu_n} < \infty.$$

ON THE NEGATIVE ORDER SUMMABILITY $\left(C, -\frac{1}{\Delta}\right)$ OF THE CONJUGATE SERIES OF FOURIER SERIES

By P. L. SHARMA

Department of Mathematics, University of Saugar

1. Let a periodic function f (t) of period 2π be integrable (L) in the interval $(-\pi, \pi)$ and let its Fourier series be

$$(1\cdot1) \quad \tfrac{1}{2} a_0 + \sum_{n=1}^{\infty} (a_n \cos nt + b_n \sin nt).$$

Then the conjugate series to the Fourier series is

$$(1\cdot2) \quad \sum_{n=1}^{\infty} (b_n \cos nt - a_n \sin nt)$$

The conjugate function associated with the series (1 2) is

$$(1\cdot3)\quad g(t) = \frac{1}{\pi}\int_0^{\pi} \psi(t) \cot\frac{t}{2}\, dt$$

where $\psi(t) = f(x+t) - f(x-t)$

The necessary condition for summability of conjugate series to the sum S by cesaro mean of negative order is that

$$g_1(t) \rightleftharpoons \frac{1}{\pi}\int_t^{\pi} \psi(t) \cot\frac{t}{2}\, dt \to S \text{ as } t \to 0.$$

The object of this paper is to prove the following theorems :

Theorem 1. If there is a $\Delta > 1$, such that

$$\int_0^t \psi(u)\, du = 0\left(t^{\Delta + 1 - \frac{1}{\Delta}}\right) \text{ as } t \to 0$$

$$\text{and } \int_0^t \left| d\left\{u^{\Delta + \frac{1}{\Delta} - 1}\, \phi(u)\right\}\right| = O(t) \qquad 0 \leqslant t \leqslant \pi$$

then the conjugate series (1·2) is summable $\left(c, -\frac{1}{\Delta}\right)$ to S at $t = x$.

Theorem 2. If there is a $\Delta > 1$, such that

$$\int_0^t \left|\psi(u)\right| du = 0\left(\frac{t^{2-\frac{1}{\Delta}}}{\log\frac{1}{t}}\right) \text{ as } t \to 0$$

$$\text{and } \int_0^t \left| d\left\{u^{\Delta + \frac{1}{\Delta} - 1}\, \psi(u)\right\}\right| = O(t) \qquad 0 \leqslant t \leqslant \pi$$

then the conjugate series (1·2) is summable $\left(c, -\frac{1}{\Delta}\right)$ to S at $t = c$.

These are analogous to the theorems of Fourier series, by the same author, which have been published in Saugar University Journal.

ON THE CESARO NON-SUMMABILITY OF THE CONJUGATE SERIES OF A FOURIER SERIES

By K. C. SRIVASTAVA

Department of Mathematics, University of Saugar

As regards the Non-summability (c, 1) of a series conjugate to Fourier series of a Lebesgue integrable function $f(\theta)$ it is well known that the existence of the conjugate function ensures summability (c, $1+\delta$) for every $\delta > 0$ at $\theta = x$. Prasad however showed by an example that the existence of the conjugate function is insufficient to imply the summability (c, 1) of the conjugate series. Misra further showed that even the condition

$$\phi(t) = \frac{1}{2\pi}\int_t^{\pi} \left\{ f(x+t) - f(x-t) \right\} \cot \tfrac{1}{2} t \, dt = s$$

$$= 0 \left\{ \frac{1}{\log \log \frac{1}{t}} \right\} \quad \text{as } t \to 0$$

fails to imply the summability (c, 1) of the conjugate series, even though the existence of the above integral obviously implies the existence of the conjugate function.

The object of the present paper is to prove that even the condition

$$\phi(t) = \frac{1}{2\pi}\int_t^{\pi} \left\{ f(x+t) - f(x-t) \right\} \cot \tfrac{1}{2} t \, dt = s$$

$$= 0 \left[\left(\log \frac{1}{t} \right)^{\alpha} \right] \qquad 0 < \alpha < \tfrac{1}{2};$$

$$\text{as } t \to 0$$

is insufficient to imply the (c, 1) summability of the conjugate series, even though the present hypothesis is more stringent than the previous ones.

ON CESARO SUMMABILITY OF ULTRASPHERICAL SERIES

By D. P. GUPTA

Department of Mathematics, University of Saugar

The ultraspherical polynomials $P_n^{\lambda}(x)$ are defined as follows:—

$$(1 - 2xt + t^2)^{-\lambda} = \sum_{n=0}^{\infty} t^n P_n^{\lambda}(x), \lambda > 0$$

If $f(\theta, \phi)$ be a function defined for $0 \leqslant \theta \leqslant \lambda$, $0 \leqslant \phi \leqslant 2\lambda$, then its ultraspherical series is

$$f(\theta, \phi) \sim \frac{1}{2\pi} \sum_{n=o}^{\infty} \iint_{S} \frac{\rho_n^{\lambda}(\cos\omega)\, f(\theta^1, \phi^1)\, d\sigma^1}{[\sin^2\theta^1 \sin^2(\phi - \phi^1)]^{\frac{1}{2}} - \lambda}, \lambda > 0$$

where $\cos\omega = \cos\theta\cos\theta^1 + \sin\theta\sin\theta^1\cos(\phi - \phi^1)$

Laplace series is a particular case of the above for $\lambda = \frac{1}{2}$. For the Laplace series, Du Plessis (Cesaro summability of Laplace series, Jour. London Math. Soc., Vol. 27,1952,337-352) has established the following result: —

If $-\frac{1}{2} < k < \frac{1}{2}$, the Laplace series of f(P) is summable (c,k) if f(P) belongs to class Lip $(\frac{1}{2}-k)$ in a certain average sense.

In the present paper we have proved the following theorem:—

Theorem:—If (1) $\lambda - 1 < k < \lambda$,

(2) $f(\theta^1, \phi^1)[\sin^2\theta^1 \sin^2(\phi - \phi^1)]^{\lambda - \frac{1}{2}}$ is L—integrable over the whole sphere

and if (3) $f(\omega) = (\sin\omega)^{1-2\lambda} \int_{o}^{2\pi} \frac{f(\theta^1, \phi^1)\, d\psi}{[\sin^2\theta^1 \sin^2(\phi - \phi^1)]^{\frac{1}{2}} - \lambda} \in \text{Lip}(\gamma - k)$

where co-ordinates $(\theta, \phi$ are so chosen that P is at the pole then the ultraspherical series of $f(\theta, \phi)$ is (c, k) summable at the point P to the value $f(\omega)$.

ON ORDER OF SUMS OF THE SERIES OF ULTRASPHERICAL POLYNOMIALS

By D. P. GUPTA

Department of Mathematics, University of Saugar

If f (x) be Lebesgue integrable in (- 1, 1), the Legendre series for f (x) is

$$f(x) \sim \sum_{n=o}^{\infty} a_n P_n(x)$$

where $a_n = (n + \frac{1}{2}) \int_{-1}^{1} f(x) P_n(x)\, dx$

This series is a particular case of

$$f(x) \sim \sum_{n-o}^{\infty} C_n P_n^{\lambda}(x)$$

where $P_n\lambda(x)$ is the ultraspherical polynomial of order λ.

and

$$C_n = \frac{\Gamma(\lambda)}{\Gamma(\frac{1}{2} + \lambda)\,\Gamma\frac{1}{2}} \cdot \frac{\Gamma(n+1)\,\Gamma(2\lambda)}{\Gamma(n + 2\lambda)} \cdot (n + \lambda) \int_{-1}^{1} (1 - t^2)^{\lambda - \frac{1}{2}} f(t) P_n^{\lambda}(t)\, dt$$

B. M. Wilson (Proc. London Math. Soc., Vol. 21, 1923, p. 390) has proved for Legendre series the following theorem :—

If $\int_0^{\lambda} f(\cos\theta)\,(\operatorname{Sin}\theta)^{\frac{1}{2}+k}\,d\theta$ exists and if $0 \leqslant k < \frac{1}{2}$

then $S_n(\cos\theta) = \sum_{\nu=0}^{n} a_\nu P_\nu(\operatorname{Cos}\theta) = \begin{cases} o(n^k) \\ o(\log n) \end{cases} \Big\} \begin{matrix} o < k \leqslant \frac{1}{2} \\ k = o \end{matrix}$

In this paper the above result has been generalised for the ultraspherical series in the following form :—

If $\int_{-1}^{1} \frac{f(x)}{(1-x^2)^{\frac{1-\lambda-k}{2}}}\,dx$ exists and if $o \leqslant k \leqslant \lambda$ where $o < \lambda < \frac{3}{2}$

then, $S_n(\cos\theta) = \sum_{\nu=0}^{n} C_\nu P_\nu^{\lambda}(\cos\theta) = \begin{cases} o(n^k) \\ o(\log n) \end{cases} \Big\} \begin{matrix} o < k \leqslant \lambda \\ k = o \end{matrix}$

ON THE SUMMABILITY [R, Log n, q] OF FOURIER SERIES AND ITS CONJUGATE SERIES

By BASUDEO SINGH

Department of Mathematics, University of Saugar

1. Let f (x) be integrable (L) over $(-\pi, \pi)$ and be periodic outside this interval with period 2π. Let the Fourier series of f (x) be

$$(1\cdot1)\quad \tfrac{1}{2}a_o + \sum_{n=1}^{\infty}\left(a_n \operatorname{Cos} nx + b_n \operatorname{Sin} nx\right).$$

Then the conjugate series of (1·1) is

$$(1\cdot2)\quad \sum_{n=1}^{\infty}\left(b_n \operatorname{Cos} nx - a_n \operatorname{Sin} nx\right).$$

We denote by $s_n = s_n(x)$ and $\bar{s}_n = \bar{s}_n(x)$ the n^{th} partial sums of the series (1·1) and (1·2) respectively. Let $\phi(t) = \frac{1}{2}\{f(x+t) + f(x-t) - 2s\}$

and $$\psi(t) = \tfrac{1}{2}\{f(x+t) - f(x-t)\}.$$

Definition. A series $\sum c_\nu$ with partial sum s_n, is said to be strongly summable by logarithmic means with index k to s or summable [R, log n, k] if there exists a finite s such that

$$(1\cdot3)\quad \sum_{\nu=1}^{n} \frac{|s_\nu - s|^k}{\nu} = o(\log n)$$

as $n \to \infty$. It is know that (1·3) does not hold if the function f (x) satisfies the condition.

$$\int_0^t |\phi(u)|\, du = o(t).$$

Hardy and Littlewood, and Sz'asz have found out sufficient conditions under which (1·3) with k=1, hold when s_ν are rearranged in the descending order of magnitude. Without imposing any such restrictions upon s_ν, we have proved the following theorems :

Theorem 1. *If* p *and* q *are conjugate indices* (i.c. $\frac{1}{p}+\frac{1}{q}=1$) *and* $q \geqslant p > 1$, *and if*

$$\int_0^t \phi(u)\, du = o(t^r)\ (r > 1) \text{ and } \int_0^t |\phi(u)|^p\, du = o\left(t \log^{p/q} \frac{1}{t}\right)$$

then $$\sum_{\nu=1}^{n} \frac{|s_\nu - s|^k}{\nu} = o(\log n)$$

for every positive $k \leqslant q$.

Theorem 2. *Let* p *and* q *be conjugate indices and* $q \geqslant p > 1$. *If*

$$\int_0^t \psi(u)\, du = o(t^r),\ r > 1$$

and $$\int_0^t |\psi(u)|^p\, du = o\left(t \log^{p/q} \frac{1}{t}\right)$$

and if the integral

$$\frac{1}{\pi}\int_0^{\pi} \psi(u) \operatorname{Cot} \frac{u}{2}\, du$$

exist as a Cauchy integral and has the value $\bar{s}$, *then*

$$\sum_{\nu=1}^{n} \frac{|\bar{s}_\nu - \bar{s}|^k}{\nu} = o(\log n)$$

for every positive $k \leqslant q$.

Theorem 3. *If for some* $r > 1$,

$$\int_0^t \phi(u)\, du = o(t^r),$$

and $$\int_0^t |\phi(u)|^2\, du = o\left(t \log^{2/q} \frac{1}{t}\right)$$

then
$$\sum_{\nu=1}^{n} \frac{|s_\nu - s|^q}{\nu} = o(\log n)$$

for all $q \geqslant 2$.

Theorem 4. *If for some* $r > 1$,

$$\int_0^t \psi(u)\, du = o(t^r)$$

and
$$\int_0^t |\psi(u)|^2\, du = o\left(t \log^{2/q} \frac{1}{t}\right)$$

and if the integral

$$\frac{1}{\pi}\int_0^\pi \psi(u) \operatorname{Cot} \frac{u}{2}\, du$$

exists as a Cauchy integral and has the value $\bar{s}$, *then*

$$\sum_{\nu=1}^{n} \frac{|\bar{s}_\nu - \bar{s}|^q}{\nu} = o(\log n)$$

for all $q \geqslant 2$.

A NOTE ON ABSOLUTE CONVERGENCE FACTORS

By O. P. VARSHNEYA

Department of Mathematics, University of Sagar

Making use of the notations of our former note, we say that the series Σu_n is absolutely summable (N;C) if

$$\Sigma |\sigma_n - \sigma_{n-1}| < \infty$$

In this note the following theorem has been established.

Theorem 1. *The necessary and sufficient condition that the series* $\Sigma u_n \varepsilon_n$ *shall be absolutely convergent, whenever the series* Σu_n *is absolutely summable* (N;C) *for a regular definition corresponding to which*

$$\sum_{n=0}^{\infty} n\,|a_n| < \infty$$

is that the sequence $\{\varepsilon_n\}$ *satisfy*

$$|C_n\ \varepsilon_n| = O(1)$$

As a particular case, the theorem given below is deduced.

Theorem 2. *The necessary and sufficient condition that the series* $\Sigma u_n \varepsilon_n$ *shall be absolutely convergent whenever the series* Σu_n *is summable* | C, r | , r *being a positive real number (including zero), is that the sequence* $\{\varepsilon_n\}$ *satisfy*

$$n^r |\varepsilon_n| = O(1)$$

ELECTRICAL CONDUCTIVITY OF GLASS FOR ALTERNATING CURRENT

By T. S. MURTY

Department of Physics, Mahakoshal Mahavidyalaya, Jabalpur

Glass behaves like an insulator at room temperature, but it becomes electrically conducting at higher temperatures. The following method was devised in the laboratory to find conductivity of glass at various temperatures.

A recess of rectangular cross-section was made in a ceramic brick and two carbon electrodes were inserted in it. Glass of a definite composition was powdered and the space between the carbon electrodes was completely filled with it. The powder was initially heated by a bunsen burner and later when it became sufficiently hot, the carbon electrodes were connected to A. C. mains due to which the glass completely melted. A calibrated thermo-couple was initially introduced in glass to measure its temperature. The resistance of the glass block was determined by putting an A. C. ammeter in series and an A. C. voltmeter in parallel with the block. With the help of a dimmerstat the heating of glass was controlled. The rate of cooling of glass was also noted.

It was noted that Rasch and Hinrichsen formula for D. C. conductivity held good for A. C. also, for a certain range of temperatures ; but it deviated at lower and higher temperatures. It was observed that the range for which the formula held good increased with the number of times the specimen was heated. It was also found that the value of the activation energy for this range was the same for different heatings of the same specimen.

THE PREPARATION OF TRANSPARENT JELLIES OF THORIUM SUCCINATE BY METATHETICAL PROCESS

By Y. D. UPADHAYA *and* S. P. MUSHRAN

Department of Chemistry, University of Allahabad

Sodium succinate and thorium chloride solutions interact to form white flocculent precipitate of thorium succinate. When the amount of sodium succinate added to thorium chloride is less than the equivalent amount the insoluble thorium succinate is held in the solution in the form of a finely dispersed colloidal state. The colloidal solution is unstable and during the course of a short time precipitation occurs. It has however been observed that in presence of small quantities of a glucose solution of suitable concentration the colloidal thorium succinate solution is suitably stabilised. The stabilised sol when left undisturbed gradually gains viscosity and in the course of a few hours sets to a firm, nonsyneretic, transparent jelly. It is further observed that the thorium succinate sol sets to a firm transparent jelly only in a very narrow range of the stabilising glucose solutions. Low concentrations fail to prevent the rapid precipitation of the dispersed phase and higher concentrations stabilise the sol to an extent that the freely moving kinetic units do not join together to form a continous framework throughout the mass of the solution.

KINETICS OF THE DECOMPOSITION OF AMMONIUM ACETATE IN ACETIC ACID SOLUTION

By A. S. DEWAGAN *and* SAMEER BOSE

Department of Chemistry, Mahakoshal Mahavidyalaya, Jabalpur

There is no reference in literature to a kinetic study of the convertion of ammonium acetate to acetamide, hence the present investigation was undertaken. The decomposition was studied by heating in sealed tubes, one c. c. of a moisture free solution of ammonium acetate in acetic acid and following it by estimating the ammonium salt by Sorensen's formol titration method. The reaction being very slow at low temperatures was studied only at temperatures above 100° by immersing the tubes in a paraffin oil bath which was thermostatically controlled. From half-life measurements and from the % decomposition at various time intervals in different solutions, the reaction was found to be unimolecular. The velocity constants calculated according to the unimolecular law drifted slightly downwards with time. Constants were determined at six temperatures ranging from 120° to 145° with various concentrations of the solution. The reactions were followed to about 60% of completion and the average velocity coefficient for particular dilution was found to agree with that determined with other dilutions at the same temperature. The deviation was not more than 4%.

On plotting log K versus reciprocal of the temperature a straight line was obtained. Arthenius energy of activation was found to be 27,000 cals. Velocity constants were also evaluated in presence of sodium acetate which increased the rate considerably. Acetic anhydride when added acted as a catalyst but failed to give kinetic constants.

CHELATE FORMATION OF URANYL ION WITH AMMONIUM AURINTRICARBOXYLATE

By ANIL K. MUKHERJI *and* ARUN K. DEY

Department of Chemistry, University of Allahabad

The formation of a coloured chelate between uranyl ion and ammonium aurintricarboxylate, with maximum absorption at 540 millimicrons, has been reported. The composition has been found to be 1 : 1, by spectrophotometric and electrical conductance studies, using Job's method of continuous variation. The structure has been discussed and it has been suggested that chelation occurs between the quinoid oxygen and the adjacent carboxylic oxygen. The formation constant at 25°C is $5{\cdot}9 \pm 0{\cdot}5 \times 10^4$, and the free energy of formation $-6{\cdot}51 \pm 0{\cdot}05$ K. cals. at the same temperature.

STUDIES ON THE PRECIPITATION OF HYDROUS THORIUM OXIDE FROM THORIUM CHLORIDE SOLUTION BY SODIUM HYDROXIDE

By RAMESHWAR PRASAD *and* ARUN K. DEY

Department of Chemistry, University of Allahabad.

It has been reported that thorium is completely precipitated from a 0·05M solution of thorium chloride by 3·8 equivalents of alkali. With increase in temperature and dilution, the value remains almost the same.

The adsorption of sodium and chlorine ions by the precipitate, in the system have been quantitatively studied. For the estimation of sodium a Flame Photometer has been used and Cl^- has been estimated volumetrically. It has been noted that the adsorption of sodium, during precipitation increase with increasing quantities of alkali used and when precipitation is complete, tends to decrease again. The adsorption of chlorine decreases continuously with increase in alkali added.

The results have been discussed and it has been concluded that there is no possibility of the formation of basic salts. A suitable mechanism for the precipitation has been suggested.

CALCULATION OF FORMATION CONSTANT, FREE ENERGY CHANGE, ENTHALPY AND ENTROPY CHANGES IN THE SYSTEM : $AgBr—NH_3—H_2O$

By ROSHAN LAL SETH *and* ARUN K. DEY

Department of Chemistry, University of Allahabad

From the data of the solubility of silver bromide in ammonium hydroxide solutions, recorded by Bodlander and Fitting, the composition of the complex formed has been found to be $AgBr, NH_3$. The method adopted for the calculation has been that suggested by Dey. These calculations have now been extended to calculate the formation constant, and the value of log K found to be 2·35 at 15°C and 2·74 at 25°C. From a knowledge of K at two different temperatures and knowing the free energy change at one of the temperatures, the Enthalpy and Entropy changes have been calculated. The values are: Free energy change at 15°C—3·26 K. Cals., Enthalpy change $1·56 \times 10^3$K. cals and Entropy change 5 4 K. cals/degree mol.

ROLE OF GREEN MANURING IN RECLAMATION

By C. L. DHAWAN, B. B. L. BHATNAGAR, B. K. HANDA & P. D. GHAI

Irrigation and Power Research Institute, Punjab, Amritsar

The following studies were undertaken on Jantar (Sesbania-aculeata), Guara (Gramopsis-psoraliodes) San (Crotalaria-Juncea)" and different types of Pulses, gram, Berseem (Trifolium-alexandinum).

(*a*) Titration curves of Juices with standard alkalis.

(*b*) Titration curves of Juices with Sodium soil.

(*c*) Behaviour of Juices in respect of their acidity value with age.

(*d*) Carbon-Nitrogen ratio of the green manures.

(*e*) Chemical analysis of the Juices.

The results of the above experiments have brought out the following salient points.

(*i*) The maximum acidity is present in Jantar (Sesbania-aculeata)

(*ii*) Jantar resists the most in increasing its pH value with age.

(*iii*) The greater the maturity of the plants, the more resistant they become in increasing their pH value with age.

(*iv*) The total nitrogen per acre is also maximum in the case of Jantar, due to its highest yield, as compared with other green manures.

(*v*) Jantar possesses the maximum percentage of calcium also.

(*vi*) Considering all the above points, Jantar behaves the best for the reclamation of alkali soils.

ADSORPTION OF CRYSTAL VIOLET ON HYDROUS CHROMIUM OXIDE

By RAJESH BEHARI HAJELA *and* SATYESHWAR GHOSH

Department of Chemistry, University of Allahabad

Hydrous chromium oxide prepared at room temperature by precipitating it with excess caustic soda and washed till free from chloride ions in the supernatant liquid having pH about eight has been found to be good adsorbent for crystal violet dye. The adsorption increases with due time and temperature and has been found that the graph between the amount of dye adsorbed on the surface with increasing time at constant temperature is linear at low concentrations of dye solution but at higher concentrations the curves become convex to the time axis further approaching towards constant adsorption with time. It has also been reported in the case of Hydrogen and Oxygen gas on zinc oxide catalyst and cobalt chromite catalyst respectively that the amount of gas adsorved increases with time being convex to the time axis.

The above result is attributed due to complexity of the crystal violet dye micelle whose size increases with the increases in the concentration of the dye in the probable manner.

$$A^n \rightleftarrows nA.$$

The slow rate of adsorption may also be due to chemisorption, chemical reaction or the solution reaction of the molecules itself.

EFFECT OF THE DILUTION ON THE ELECTRICAL CONDUCTANCE AND pH OF THE HYDROUS FERRIC OXIDE SOLS OF DIFFERENT GRAIN SIZES

By DILAWAR SINGH *and* SATYESHWAR GHOSH

Department of Chemistry. Allahabad University

The present paper deals with the study of the effect of dilution on the electrical conductance and pH of the hydrous ferric oxide sols having colloidal micelles

of different grain sizes. It has been shown by us that the colloidal hydrous ferric oxide tends to behave as colloidal electrolyte when the grain size is very small.

Four samples of the hydrous ferric oxide sols, were obtained with the Sharple's Supercentrifuge keeping it at the speeds 4000, 9000, 16000 and 24000 r.p.m. For the purpose of study all the four Sols were made to contain the same amount of iron per litre of the sol, by diluting wherever necessary. By estimations it was observed that the colloidal solution having smaller grain size possessed more chloride than the sol containing bigger colloidal micelles.

The results here show that with the dilution of hydrous ferric oxide sol there occurs desorption of hydrogen ions from the surface of the colloidal particles, which cause the liberation of chloride ions from the double layer making them osmotically active. These desorbed hydrogen ions and liberated chloride ions increase the specific conductance of the diluted sol but the decrease in the charge on the surface of the colloidal particles makes their electrical conductance contribution less. It has been shown in this paper that with the dilution of hydrous ferric oxide sol the factor,

$$\frac{\text{Sp. Conductance}}{[H]}$$

if plotted against dilution decreases slowly and passes through a minimum point, then increases and finally again decreases after passing through a maximum point. This minimum point is more prominent in the case of sol possessing smaller colloidal micelles than one containing bigger colloidal micelles.

This behaviour is explained from the fact that with progressive dilutions of the sol, more and more hydrogen ions become available in the system, because of their release from the colloidal surface. With subsequent decrease in the charge of the colloidal particles, leads to a decrease in the conductance contribution of the colloidal particles. Hence it appears that the decrease in the conductance of the colloidal particles with increasing dilutions is less rapid than the release of the hydrogen ions from the colloidal surface. The release of the hydrogen ions from the colloidal surface is rapid in the earlier stages of dilution than afterwards.

TITANIUM PHOSPHATE: PRECIPITATION AND SOLUBILITY

By N. R. DHAR *and* K. M. VERMA

Sheila Dhar Institute of Soil Science, University of Allahabad

It has been observed that titanium phosphate when precipitated in acidic medium and dried at room temperature is of the composition $2TiO_2 . P_2O_5 . 10{\cdot}6H_2O$. The titanium phosphate precipitated in alkaline medium undergoes hydrolysis, becomes more basic and has the composition $2{\cdot}7TiO_2\ P_2O_5 . 10{\cdot}6H_2O$. The addition of $CaCO_3$ increases the solubility of the phosphate in water while neutral salts donot seem to have any appreciable effect on the solubility of the titanium phosphate.

TITANIUM PHOSPHATE : SOLUBILITY IN WEAK ACIDS AND ALKALIES

By N. R. DHAR *and* K. M. VERMA

Sheila Dhar Institute of Soil Science, University of Allahabad

Carbonic acid does not seem to have any marked influence on the solubility of the phosphate while organic acids, e.g., acetic, tartaric and citric increase the solubility of the phosphate by forming complexes. Citric acid causes the maximum solubility followed by tartaric and acetic acids. Alkalies have a decomposing influence on the titanium phosphate the greater the concentration of the alkali, the greater the decomposition of titanium phosphate into titanium oxide and alkali phosphates.

EFFECT OF TEMPERATURE, RELATIVE AMOUNTS OF SOLID PHOSPHATE AND WATER AND CALCIUM CARBONATE ON THE SOLUBILITY OF SOME METALLIC PHOSPHATES

By N. R. DHAR *and* K. M. VERMA

Sheila Dhar Institute of Soil Science, University of Allahabad

All the metallic phosphates undergo hydrolysis in water. The hydrolysis of the phosphates increases with increase in the temperature and with decrease in the ratio of solid phosphate to water i.e., when the amount of salts are increased from 1 gm. to 2 gm. With respect to the ability of the phosphates to hydrolyse they can be placed in the following decreasing order :—

$$Sr_3(PO_4)_2 > Ca_3(PO_4)_2 > Zn_3(PO_4)_2 > FePO_4 > CaHPO_4 > Ba_3(PO_4)_2 > Mn_3(PO_4)_2 > Fe_3(PO_4)_2.$$

Addition of $CaCO_3$ checks the hydrolysis of the barium, strontium, tricalcium, dicalcium, manganese and zinc phosphates while ferric phosphate is more hydrolysed. Ferrous phosphate on the other hand is very slightly affected.

SOLUBILITY OF METALLIC PHOSPHATES IN NEUTRAL SALT SOLUTIONS

By N. R. DHAR *and* K. M. VERMA

Sheila Dhar Institute of Soil Science, University of Allahabad

Neutral salts increase the solubility of the phosphates of barium, strontium, tricalcium, dicalcium, manganese and zinc. The salts having the sulphate ion effect the maximum solubility followed by chlorides and nitrates, while with basic radicals the order is $NH_4 > Na > K$. On the other hand, ferric and ferrous phosphates do not show any marked influence of neutral salts.

ACTION OF CARBONIC ACID ON THE SOLUBILITY OF METALLIC PHOSPHATES

By N. R. DHAR *and* K. M. VERMA

Sheila Dhar Institute of Soil Science, University of Allahabad

It has been observed that carbonic acid increases the solubility of the phosphates of barium, strontium, tricalcium, dicalcium, manganese and zinc and with increased concentration it goes on increasing while it has a feeble depressing effect on the solubility of ferric and ferrous phosphates.

STUDIES ON THE SOLUBILITY OF METALLIC PHOSPHATES IN WEAK ORGANIC ACIDS

By N. R. DHAR *and* K. M. VERMA

Sheila Dhar Institute of Soil Science, University of Allahabad

The organic acids increase the solubility of barium, strontium, tricalcium, dicalcium, manganese, zinc, ferric and ferrous phosphates. Citric acid causes the maximum solubility followed by tartaric and acetic acids. The solubility of barium strontium, tricalcium, dicalcium manganese and zinc phosphates is increased to a much greater extent than ferric and ferrous phosphates.

DECOMPOSITION OF THE METALLIC PHOSPHATES BY THE ACTION OF ALKALIES

By N. R. DHAR *and* K. M. VERMA

Sheila Dhar Institute of Soil Science, University of Allahabad

Alkali solutions exert a much greater decomposing influence on manganese, zinc, ferric and ferrous phosphates than barium, strontium, tricalcium and dicalium phosphates. Concentrated solutions of alkalies decompose more than dilute ones liberating the corresponding amounts of soluble phosphates passing into the solutions.

CHELATE FORMATION BETWEEN AMMONIUM VANDATE AND SODIUM ALIZARIN—3—SULPHONATE : A SPECTROPHOTOMETRIC STUDY

By SAMIR K. BANERJI *and* ARUN K. DEY

Department of Chemistry, University of Allahabad

The work is a continution of the work on chelates involving alizarin—3—sulphonate, reported from these laboratories. Job's method of continuation variation has now been applied to the absorption spectra studies of the system: $NH_4\ VO_3$ - ARS - H_2O, for the study of the chelate formed in the system. The chelate has an orange-red colour with maximum absorption at 465 millimicrons and the colour is stable for long periods. The composition, structure and free energy of formation has been studied.

CHROMATOGRAPHIC STUDY OF ANIONIC COMPLEXES OF METALS WITH OXALATE, CITRATE AND TARTRATE

By ERIC JOHN SINGH *and* ARUN K. DEY

Department of Chemistry, University of Allahabad

Mixtures of metal salts and carboxylic acid having varying composition have been prepared and the movement of ion through filter paper strips, by the ascending method, has been studied. The solvent used is 50% ethanol. Information on the behaviour of the anionic complexes has been derived from a consideration of the R_f values.

STUDIES ON SILVER CITRATE COMPLEXES : AN ANALYTICAL STUDY

By KRISHNA C. MATHUR *and* ARUN K. DEY

Department of Chemistry, University of Allahabad

Varying amounts of trisodium citrate, disodium hydrogen citrate and tripotassium citrate have been added to silver nitrate solution and the amount of silver ion in the supernatant liquid estimated. The silver ion decreases first with gradual addition of the citrate and as dissolution of silver to form the complex proceeds, silver in the supernatant liquid increases again, till complete dissolution occurs. The data have been critically examined to throw light on the conditions of the formation of of the soluble argentocitrate complex.

CHELATE FORMATION BETWEEN METAL IONS AND SUBSTITUTED THIOUREA DERIVATIVES

By SURESH CHANDRA SRIVASTAVA *and* ARUN K. DEY

Department of Chemistry, University of Allahabad

p-bromo-phenyl—, p-ethoxy-phenyl—, p-tolyl—, m-tolyl— and o-tolyl-thiourea have been prepared by suitable condensation. These compounds form insuluble chelates with various metal ions, which have been studied. The possibility of using these cor pounds as precipitants for metals is being examined.

CHEMICAL SOIL CONDITIONER FOR THE RECLAMATION OF ALKALI SOILS

By C. L. DHAWAN, M. M. LALL MALHOTRA *and* JAGIR SINGH

Irrigation & Power Research Institute, Puujab, Amritsar

Semi field experiments were carried out in plots measuring $5' \times 4'$ in which the percentage of Kirilium ranged from 5 pounds per acre to 500 pounds per acre. The results of two years crop rotations with Rice-Sugarcane showed that neither the degree of alkalisation nor pH were lowered, except a little increase in the yield of the respective crops in plots, containing Krilium more than 100 pounds per acre. The results further confirm the findings of Dhawan and his co-workers based on laboratory experiments that Kirilium cannot be employed for the amelioration of alkali soils.

SUITABILITY OF CROPS UNDER WATER LOGGED CONDITIONS

By C. L. DHAWAN, M. M. LALL MALHOTRA *and* JAGIR SINGH

Irrigation & Power Research Institute, Punjab, Amritsar

Semi-field experiments were conducted in plots, measuring 9' ×5', having pucca floor at 1 ft, 2 ft., 3 ft., 4 ft., and 4 ft., 9 inches depth. From the results of experiments on wheat, cotton, senji (MELILOTUS-PARVIFLORA), sugar cane, the following broad conclusions were drawn : —

(*a*) Wheat did fairly well upto 2' of water table. Only one irrigation was was given to 4 ft. and 4 ft. 9 inches. If another irrigation would have been given to 4 ft., 9 inches, the yield would have been better.

(*b*) Cotton was a complete failure upto 3 ft. depth of water table and even the crop was not normal at 4 ft. depth. The crop presented normal growth at 4 ft., 9 inches depth.

(*c*) Senji did fairly well in all the plots.

(*d*) Sugar Cane was best in plots having water table at 2 ft., and 3 ft., depths. One Irrigation was applied to crops sown in a plot having water table at 4 ft., depth and two Irrigations were given to the fifth plot, having water-table at 4 ft., 9 inches depth.

AMINOACIDS IN SOILS CROPPED WITH JUTE: I: EFFECT OF FERTILISERS

By M. K. MUKHERJEE *and* A. K. BANERJEE

Jute Agricultural Research Institute, Barrackpore, West Bengal

Free aminoacids present in the soil were extracted with 80% alcohol immediately after collection of the samples. The extract was evaporated to dryness on waterbath. The free aminoacids were extracted by a definite but small volume of alcohol from the dried mass. Chromatograms were obtained from this extract by the usual technique. R_f values were calculated and aminoacids were identified from the R_f values. The intensity of the spots was taken as the index of relative concentration of the free aminoacids.

The soil samples used in these experiments were collected after a period of six weeks from the date of sowing of Jute. The fertilisers were applied in the usual way *i.e.* superphosphate and compost as basal dressing whilst ammonium sulphate was given as a topdressing after a period of one month from the date of sowing.

It has been found that the fertilisers *viz.* ammonium sulphate & superphosphate and town compost exert considerable influence on the presence of free aminoacids in the soils. Ammonium sulphate has generally depressed the formation of free aminoacids particularly alanine, valine and leucine in soils. Superphosphate and compost have generally encouraged the formation of free aminoacids in soils particularly of alanine, valine and leucine. With the application of increasing doses of compost to the soils, the amount of these aminoacids in the free state increases. Ammonium sulphate when applied with superphosphate or compost depress the formation of these aminoacids in the free state.

No spot for glycine and cerine was obtained in the extract from soil samples obtained from plots receiving compost either alone or in combination with ammonium sulphate. With higher doses of ammonium sulphate alone, however, faint spots of these aminoacids were obtained in the chromatograms but in plots receiving ammonium sulphate and superphosphate together the presence of these two aminoacids in the free state were pronounced.

Aspartic acid was found to be present in free state in plots receiving compost or superphosphate. In plots receiving lower doses of ammonium sulphate, aspartic acid could not be detected but at higher doses, its presence could be detected. The presence of aspartic acid was pronounced in plots treated with ammonium sulphate and compost together and became more pronounced when superphosphate was added with ammonium sulphate.

FIXATION OF ATMOSPHERIC NITROGEN IN THE INCUBATION OF STRAW AND LOSS OF NITROGEN FROM STRAW MIXED WITH LARGE AMOUNTS OF NITROGENOUS COMPOUNDS

By N. R. DHAR *and* A. C. GAUR

Sheila Dhar Institute of Soil Science, University of Allahabad

When straw is incubated at 35°C for 3 months and allowed to undergo exidation with water only in presence of air, 61.6% carbon is oxidized and marked nitrogen fixation *i.e.* 38.8% of the total nitrogen present, as observed. The efficiency of nitrogen fixation *i.e.* the amount of nitrogen fixed in mgms per gram of carbon oxidized, is 7.8. When nitrogenous substances in the form of urea or ammonium sulphate are added, so that the initial nitrogen content of the system is increased and the C/N ratio is decreased, a copious loss of nitrogen is observed.

When nitrogenous substances are added to straw in small doses, an appreciable nitrogen fixation takes place. In presence of phosphates the loss is minimised and the nitrogen fixation is enhanced.

BIOLOGICAL SCIENCES SECTION
ABSTRACTS OF PAPERS

CULTURAL-CUM-MANURAL STUDIES ON WEEDS OF WHEAT FIELD

By R. N. KAUL

Soil Conservation Research Demonstration and Training Centre, Dehra Dun

This paper outlines the effect of different levels of cultivation, weeding and manure $(NH_4)_2 SO_4$ on (1) sequence of appearance of different species of weeds, (2) proportion of total and individual weeds to wheat crop at various stages of the life cycle of wheat, (3) density of weeds under conditions of high and low farming (3, 6, 9 and 12 plowing, one weeding, two weedings and no weeding and nitrogen and no nitrogen) (4) amount of Nitrogen removed by each species of weed and finally the effect of weeds on the crop yield. The data relate to an investigation carried out at the Indian Agricultural Research Institute, New Delhi during the season of 1951-52.

It was observed that *Cynodon dactylon* and *Cyprus rotundus* were the first and *Phyllanthus niruri* was the last in succession of weeds. *Cypreus rotundas, Chenopodium album* and *Melilotus indica* held the dominant position throughout the major part of the life cycle of wheat crop in comparison with the other eleven species of weeds that appeared in small numbers during different stages of the life cycle of the crop.

Intensive ploughings (6,9 and 12 ploughings) exhibited less number of weeds associated with the crop as compared to the crop under 3 ploughings. The percentage reduction of weeds under N1 (40 lbs N as $(NH_4)_2 S0_4$ per acre) was 11·79 over the check. The reduction of weed population under high farming may be explained on the basis of (1) better stand of the wheat, no doubt had a smothering effect that reduced weed population, (2) frequent stiring of the soil under 6,9 and 12 ploughings might have resulted in displacement of seeds of various weeds from their optimum depth for germination (3) addition of $(NH_4)_2 S0_4$ may have brought some change in the pH of the soil thereby retarding germination of some of the weed species which need a certain range of pH for their germination.

Melilotus indica removed a fairly high proportion of soil nitrogen followed by *Chenopodium abum, Anagalis arvensis* and *Fumaria parviflora.*

One weeding produced the highest grain yield (8·3 mds/acre), 38·1% over no weeding. Two weedings however produced significantly greater yield (7·6 mds/acre) over no weeding (6·0 mds/acre) the percentage increase being 26·8.

A TAXONOMIC STUDY OF SOME SAPROLEGNIACEAE OF ALLAHABAD

By RAM DAYAL

Department of Botany, University of Allahabad

A survey of the waters from various ponds and ditches of Allahabad, has been made. A number of aquatic fungi were isolated and their pure cultures have been made. They included a few members of the order *Saprolegniales*, which have been

described and others are under study. The species described are *Saprolgenia parasitica* Coker, *Isoachlya Unispora*, Coker & Couch, *Isoachlye toruloides* Kauffman and Coker, *Achlya aplanes* Maurizio. Var, indica, Saksena & Dayal, *Achlya flagellata*, Coker and two sterile *Achlyas*. Of these two, viz *Isoachlya unispora* and *Isoachlya toruloides* are new from this country. A new variety of *Achlya aplanes* is also reported, while others are new from Uttar Pradesh. They have been cultured on hemp seeds and various other media. Their characters have been studied and described in detail along with diagrams. Differences if any, from the older descriptions have also been reported.

THE CLASSIFICATION OF DIGENETIC TREMATODA

By H. R. MEHRA

A system of natural classification must be based on phylogenetic relationships, and with that in view La Rue in 1926 laid a key note for a revision of the classification of the Digenea and created the Order Strigeatoidea under it. Szidat in 1936 created another Order Fasciolatoidea on the basis of similarity between the life cycles and larval stages of the Paramphistomidae and Notocotylidae placing them in the Suborder Paramphistomata under it. In 1937 Szidat showed fundamental similarity in structure and life cycles of the Psilostomidae and Echinostomatidae, and in 1939 created the Suborder Echinostomata under Fasciolatoidea to include the families Echinostomatidae, Psilostomidae and Fasciolidae.

La Rue in May 1957 has given a system of classification based largely on similarities in the life cycles and development of larval stages and of the excretory system, but it needs modifications. In our opinion his Superorders Anepitheliocystidia and Epitheliocystidia are unnecessary and therefore should be dropped, as development of the epithelial excretory bladder in the cercariae of the latter is considered as a secondary character having no palingenetic significance and showing no closer relationship of some groups included under it to one another than to some groups of the former. As for instance the Suborders Echinostomata and Paramphistomata of the Anepitheliocystidia are more closely related to the Plagiorchiata and Opisthorchiata than to the Suborders Brachylaemata Mehra, 1950 and Strigeata La Rue, 1926. The Suborder Cyclocoelata which is more closely related to the Paramphistomata Notocotyloidea of the Order Fasciolatoidea than to the Order Strigeatoidea is thus also closely related to the Order Plagiorchiida. The loss or great reduction of tail in the cercariae has apparently taken place separately by convergence in some grops as an adaptation in a life cycle in which the free swimming stage is ommitted as pointed out by Cort (1918) and Wallace (1941), therefore Cyclocoelata is not considered to be closely related to Brachylaemata and hence the Strigeatoidea. The relationships of the various subdivisions are thus not clear in this new System of classification dividing the Digenea into the Superorders created by La Rue. A comparison of the development of the excretory system from the embryo to mature cercariae indicates that the entire excretory system minus the development of the definitive excretory bladder in mature cercariae should constitute an important basis of classification with some other features of the developmental stages and the adult, and this invalidates the Superorders.

The Order Echinostomida La Rue, 1957 must be dropped and replaced by the Order Fasciolatoidea Szidat, 1936 on the basis of priority.

The Orders Plagiorchiida La Rue, 1957 and Opisthorchiida, La Rue, 1957 are accepted.

A new Order Azygiatoidea is created to accommodate the Suborder Azygiata with the Superfamily Azygiodea Skrj, and Guschansjaja, 1956 on account of the gigantic furcocystocercous cercariae with flame cell groups in the tail, which develop in sausage-shaped rediae with terminal rudimentary pharynx but without gut and locomotor appendages; genital opening in front of oral sucker; miracidia probably non-ciliate.

Another new Order Hemiuratoidea is created to accommodate the Suborder Hemiurata Skrjabin and Guschanskaja as the latter is sufficiently distinctive from the Suborder Opisthorchiata so as to be separated from it under a separate Order on account of the cystophorous or Hemiurid cercariae and the primitive type of development of the excretory system, the fused tubes extending to the tip of one part of the highly modified tail. Cercariae develop in rediae; second intermediate host a Copepod; miracidia non-ciliate.

The evolution of the Digenea has probably taken place along three lines of evolution from the primitive digenetic ancestor, one line giving the Orders Strigeatoidea, another line resulting in the Orders Fasciolatoidea, Plagiorchiida and Opisthorchiida and the third line giving the Orders Hemiuratoidea and Azygiatoidea. An outline classification of these Orders into suborders, superfamilies and families is given.

OCCURRENCE OF TWO SPECIES OF THE CESTODE, *OOCHORISTICA* LUHE, 1898 IN A SOUTH INDIAN LIZARD

By G. N. JOHRI

Department of Zoology, University of Lucknow

Two species of cestodes have been described from the lizard, *Calotes versicolour* Daudin caught in the vicinity of Mandapam, South India. *Oochoristica mandapamensis* sp. nov. is charaeterised by the possession of the testes in two distinct lateral groups extending beyond the longitudinal excretory vessels and has been separated from *Oochoristica crinacei* Meggitt, 1920; *Oochorictica pennsylvanica* Chandler and Melvin, 1951 and *Oochoristica theileri* Fuhrmann, 1924 with which it resembles. *Oochoristica lygosomatis* Skinker, 1935 from the same host has been described and figured.

AN ECOLOGICAL SURVEY OF GOKALPUR LAKE (JABALPUR M. P.) WITH SPECIAL REFERENCE TO ITS FISH FAUNA

By R. B. MALVIYA

Department of Botany, Mahakoshal Mahavidyalaya, Jabalpur

The paper deals with the preliminary ecological investigation of the fish fauna of Gokalpur Lake Jabalpur, (M. P.) An effort has been made to evaluate possible factors governing the distribution of fishes in the lake.

The lake is not a natural one but has been classified as biotic. Situation, topography, climate and vegetation of the lake have been described in short. After dealing with the general survey of the aquatic fauna, fishes collected from the lake have been tabulated giving their size, depth of netting, their local names and the type of nets which were used in their catches. Twenty eight species of fish have been collected so far. All of them belong to the order *Teleostei*. Of these species 9 belong to the family *Cyprinidae* 1 to *Clarridae*, 1 to *Heteropneustidae*, 2 to *Bagridae*, 1 to *Siluridae*, 3 to *Schilleidae*, 3 to *Ophiocephalidae*, 2 each to *Nandidae* and

Mastaacembalidae, and 1 species, respectively, to *Notopteridae*, *Cobitidae*, *Belonidae* and *Percidae*.

Migration of fishes is a probability since a 'canal' pours into the lake periodically. The local distribution of fishes has been discussed to probably depend upon:—

(*i*) availability of plants and zoo-organisms depending upon 3 zonal distribution of vegetation,

(*ii*) penetration of light governed by luxuriance of vegetation and turbidity, and

(*iii*) hydrostatic pressure, depending upon the volume of water at different depths.

THE CULICINE FAUNA OF CHOTANAGPUR PLATEU (BIHAR)

PART 1—INDIAN SPECIES OF CULEX (CULEX), WITH A NOTE ON THEIR BIONOMICS AND A KEY

By P. N. MEHROTRA

Department of Zoology, Bihar University, Ranchi

Breeding habits, habitats and resting places of nine species of *culex* (*culex*) viz. *epidesmus*, *sinensis*, *edwardsi*, *bitaenorhynchus*, *barraudi*, *mimeticus*, *fatigans*, *hutchinsona* and *fuscitarsis* have been described and distribution in Chotanagpur studied. Except *C. fuscitarsis*, the other eight species have been recorded for the first time from Chotanagpur. Graphs showing annual cycle in the population of three species most common in Ranchi have also been given.

NITROGEN NUTRITION OF *PHYLLOSTICTA ARTOCARPINA* (SYD ET BUTL)

By R. N. TANDON *and* K. S. BILGRAMI

Department of Botany, University of Allahabad

The influence of 26 different sources of nitrogen was studied on the growth of *Phyllosticta artocarpina* (Syd et Butl). The organism belonged to group II of Robbins's classification as it failed to assimilate atmospheric nitrogen. Nitrites inhibited the growth. Nitrates of inorganic salt, dl-valine, glutamic acid, aspartic acid, aspargin, arginine, peptone and urea were significantly good sources of nitrogen. Poor growth was recorded on ammonium comounds, glycine, serine, leucine and histidine.

Chromatographic studies showed that there was no antagonestic effect of different amino acids and even the poor sources of amino acids did not adversely influence the growth when they were given in combination with good amino acids.

There was no correlation between growth and sporulation. It has been established that in general the nitrogen requirement of *P. artocarpina* is similar to that of *P. cycadina* except for comparatively poor growth on histidine and tyrosine.

SULPHUR AND PHOSPHORUS REQUIREMENTS OF CURVULARIA PENNISETI

By G. P. AGARWAL

Department of Botany, Mahakoshal Mahavidyalaya, Jabalpur

Sulphur and phosphorus requirements of *curvularia* isolated from *Pennisetum typhoideum* have been studied.

The fungus was able to develop some growth without any sulphur. Magnesium sulphate, sodium sulphate and sodium bisulphate supported the best growth. Good growth of the organism was obtained on potassium sulphate and sodium thiosulphate. Growth was moderate on sodium sulphite. Ammonium sulphate and thiourea supported only poor growth. The fungus failed to grow on potassium persulphate and sodium bisulphate but at very low concentrations some growth was obtained. These two compounds appeared to be toxic. Amongst the sulphur compounds tried only magnesium sulphate could support good sporulation of this organism. Sporulation was vary poor, rare or nil on other sulphur compounds. There was no sporulation on medium lacking sulphur. Increase in the amount of sulphur as magnesium sulphate up to 4% increased the growth of the fungus but subsequently increases in dose had adverse effect.

It developed some growth on a medium lacking phosphorus. KH_2PO_4 was the most suitable source of phosphorus followed by K_2HPO_4 and K_3PO_4. The growth on KH_2PO_4 and K_2HPO_4 increased up to 0.1599 % P while on K_3PO_4 up to 0.0399% P only, beyond which it decreased. The final reaction of the nutrient media showed a definite correlation with the fall in the dry weights of the organisms.

THE ROOT SYSTEMS OF *TEPHROSIA PURPUREA* AND *ACANTHOSPERMUM HISPIDUM* ON DIFFERENT GEOLOGOCAL FORMATIONS OF JABALPUR

By S. N. AWASTHI

Department of Botany, Mahakoshal Mahavidyalaya, Jabalpur

Our knowledge of the interaction between the soil, roots and the neighbouring root systems is very scanty. According to Russell (1953) the soil effect the plant primarily through its effect on the root system. A number of factors have been known to effect the development of roots.

The present study aims to correlate the root systems of *Tephrosia purpurea* and *Acanthospermum hispidum* with some physical characters of the soil as they exist on different geological formations of Jabalpur.

The roots have been studied in the following formations :—

(i) Calcareous clays, (ii) Sandstones, (iii) Alluvium (River Narmada Ravines), (iv) Basalt soil (Black), (v) Laterite and (vi) Granite soil.

In general the roots are more branched in alluvium and basalt black soil. Granite and laterite soils have longer roots. Basalt and alluvium soils have high percentage of clay and low sand ; whereas granite and laterite soils have high sand

percentage. Total soil moisture is highest in basalt soils. Granite, laterite and sandstone soils have greater porosity of soil, being 43 to 44%. The field capacity is greatest in basalt black soils and least in sandstones and calcareous clays.

The data have been further correlated with the different zonations of the soil profiles in the different soil types. The results have been indicated graphically.

ROOT COMPETITION AND TRANSPIRATION STUDIES ON SAL SEEDLINGS

By HARISH BHATNAGAR

Forest Research Institute, Dehra Dun

Adverse moisture balance is supposed to be one of the many causes of the failure of natural regeneration of sal (*Shorearobusta*) in the forests of India. For knowing the comparative utilization of and competition for available moisture studies on transpiration of sal seedlings and of its common associated species were done in the Demonstration Area along with assessment of root competition of sal seedlings with other ground floor vegetation in trenched, untrenched, weeded and unweeded plots.

Probably sal seedlings require more moisture than what is available to them, which is due to the competition for available water by the presence of other species in abundance. The studies show that Mallotus philippensis is probably the chief competitor for soil water, its rate of transpiration being comparable to that of sal. Since Sal seedings transpire more in weeded plots, it is also evident that weeds do exert a substantial inhibiting influence on their growth. Correspondingly the rate of height growth is faster in the weeded plots. As water is of paramount importance in the physiology of plants it is stressed that the soil moisture relations of bad y regenerated areas and good regenerated areas should be worked out completely, and as the intake of water and its loss is conditioned by the environment, fruitful results can be reached if we combine ecological and physiological research together.

STUDIES ON "HEAD MOULD" DISEASE OF *SPOROBOLUS DIANDER*. BEAUV.

By R. Y. ROY *and* S. NARASIMHA RAO

Department of Botany, Banaras Hindu University

Helminthosporium ravenelii Curt. and Berk. Affected floral parts covered with velvety olive brown mass of hyphae; conidiophores branched and in masses appear light sooty coloured, 4·5 to 7 μ in diameter and upto 120 μ long, septate at intervals of 15-30 μ; spores many at the apices and at the geniculations, 1-5 septate (usually 3 to 4) 45-66 $\times$ 12-15 μ, rounded at both ends.

Habitat: On florets of *Sporobolus diander*. Beauv. 17th August, 1957.

SOIL PROFILES ON DIFFERENT GEOLOGICAL FORMATIONS OF JABALPUR

By M. D. DUBEY

Department of Botany, Mahakoshal Mahavidyalaya, Jabalpur

The present investigations have been undertaken to study the development of soil on the different geological formations under Jabalpur climate. The profiles under study have been dug in grazed grasslands on the different formations.

5 ft. deep soil profiles have been studied in basalt black soil, laterite, granite, sandstones, alluvium (River Narmada Ravines) and calcareous clays. The profiles have been studied for the followings :—

pH, sesquioxides, total nitrogen, organic carbon and exchangeable calcium.

The results are :—

(*a*) Except in calcareous clays, the soil pH has been found to increase with depth. Sandstones and laterite soils are acidic and the rest basic.

(*b*) Sesquioxides-laterite, granite and basalt soils have high percentage of sequioxides. The percentage increases with depth. Calcareous clays did not record and sequioxides.

(*c*) Total nitrogen-increases with depth upto about 4 ft. after which the value decreases.

(*d*) Organic carbon has been found to decrease with depth. Calcareous clays have lower values.

(*e*) Soil exchangeable calcium fluctuates with depth. Basalt and alluvial soils have higher percentage of this element.

SOME *SOIL FUNGI* OF VARANASI

By R. S. DWIVEDI

Department of Botany, Banaras Hindu University

Soil fungi were isolated and studied from two different grasslands at the depths of 4", 12" and 20" Surface vegetation was also studied from the point of view of frequency, dominance and abundance of each species. The following is the description of some of the fungi :—

(1) *Aspergillus lutescens* Bainier and *Botrytis cinerea* Persoon have been obtained, which is the first record from Indian soil.

(2) *Pestalotia* sp. and *Paecilomyces fusisporus* Saksena S. B., second record from soil.

(3) *Thielavia* sp. and *Neocosmospora* sp. have been isolated. Species identification remains to be done.

(4) Two species of *Aspergillus* have been isolated which are peculiar and differ from previously described species of the genus in having proliferation of sterigmata into very long secondary and tertiary conidiophores. Besides, one of them shows proliferation of sterigmata into sterile hyphae. Further study of both of them is in progress in order to determine the species.

NOTES ON THE AUTECOLOGY OF *CROTALARIA MEDICAGENIA* LAMK

By C. R. RUGMINI

Department of Botany, Banaras Hindu University

Crotalaria medicagenia Lamk. is an erect road side and pestureland weed growing gregariously in the rainy season. A shorter form in isolated populations is found in the winter. Its geographical and ecological distribution is described. Stomatal

frequency and seed germination have been studied in some detail. The former is related to some extent to light intensity. Percentage germination at 32°C is maximum. There is no dormancy in the seeds. pH range for germination is found to be 7—10.

ON THE PHYTOSOCIOLOGY OF SOME *ANOGEISSUS LATIFOLIA* FOREST OF MADHYA PRADESH

By S. R. JOSHI

Department of Botany, Mahakoshal Mahavidyala, Jabalpur

Anogeissus latifolia is a wide spread tree species distributed throughout Madhya Pradesh. It has been classed to belong to miscellaneous type of forest in this state. The species however never forms a pure forest. It was with the view to ascertain the status of this species in M. P. forests that this phytosociological study has been undertaken. The study covers "Miscellaneous forest" of Jabalpur, Narmada Ravins, Katangi, Shahsgad, Nepanagar and Sal forests of N. Baster, Raipur, Balaghat (Mukie), and Pachmari divisions. The teak forests of Patharia and Badwani were also examined.

The forests have been studied by belt transect 25 ft. wide and run across the contours. At least ten belt transects have been studied in each forests. The paper gives the quantitative, qualitative and synthetic characters of forests. In total about 50 species have been reported to grow with *Anogeissus latifolia.* From a close study of synthetic characters of forests it appears that *Anogeissus latifolia* is a transetional species discharging a peculiar role. On one hand it appears to take over from such low species as *Carissa spinarum Lagerstroemia parviflora Zizyphus sp. Celastrus malcanei, Butea monosperma, Woodfordia floribunda, Diospyros melanoxylon, Lantana camara* etc. and on the other hand it probably merges into dense forests of Sal and Teak. In opean forests dominated by the aforsed species *Anogeissus latofolia* has a shrubby habit. In Shahagad, Katangi, Nepanagar, Patharia and Pachmari the trees are as tall as 50-60 ft. with smooth, greyish patched bark.

The Density diagrams of different forests have been given. Polygraphs showing Abundance, Frequency and Cover of *Anogeissus latifolia* have also been given.

ECOTYPIC DIFFERENTIATION IN SOME PLANTS OF VARANASI

By P. S. RAMAKRISHNAN

Department of Botany, Banaras Hindu University

A preliminary account of ecotypic differentiation in *Euphorbia hirta,* Linn., *Echinochloa colona,* Link., *Euphorbia thymifolia,* Linn., and *Setaria glauca,* Beauv., is given below :—

In *Euphorbia hirta,* Linn., two ecotypes and two ecads for one of the ecotypes have been differentiated.

Ecotype No. 1:—*Erect type*—growing in moist localities.

Ecotype No. 2:—(*a*) Ecad No. 1: *Prostrate type*—growing in dry hard soil.

(*b*) Ecad No. 2: *Prostrate cushion type* derived from the above from under trampling on foot paths.

Similarly, two ecotypes related to soil moisture have been differentiated in *Echinochloa colona*, Link.

Ecotype No. 1:—*Tall form*—growing in water-logged soils along the margin of shallow ponds and drainage channels.

Ecotype No. 2:—*Short form*—growing in comparatively drier localities.

The *tall form* is found to have longer leaves, longer internodes and more growth and compared to the *short form*.

In *Euphorbia thymifolia*, Linn., two ecotypes are recognised in the field :

Ecotype No. 1:—*Coppery Red form*—having a coppery red tinge throughout the plant body.

Ecotype No. 2:—*Green form*.

These two forms are distinct populations as shown by transplant experiments. The *coppery red form* occurs either on soils rich in exchangeable calcium, or also on calcium poor soil in association with the *Green form*. In other words, *coppery red form* can grow in localities where *green form* grows, but the reverse is controlled by the amount of calcium in the soil. The two populations keep distinct, in spite of interbreeding. Further genecological work is in progress.

In *Setaria glauca* Beauv., three different populations are recognised in the field :

1. *Long panicled form*—growing in moist clayey soils.
2. *Short panicled form*—growing in dry loose loamy soils.
3. *Intermediate form*—growing on the tops of old walls and buildings.

Genecological work is in progress to reveal the nature of these different populations.

COMPOSITION OF SOME SAL (*SHOREA ROBUSTA* GAERTN) FORESTS OF MADHYA PRADESH

By N. K. JAIN

Department of Botany, Mahakoshal Mahavidyalaya, Jabalpur

As far as the author is aware there is no work as yet on the phytosociology of Sal forests of Madhya Pradesh. The present investigations were, therefore, undertaken to study the pattern of distribution of Sal and its associates in the localised Sal regions of this state. This may give basis for further investigations on the ecology of Sal.

The Sal regions under investigation are : Balaghat division (Mukie), Hoshangabad division (Pachmarhi) Raipur division (Nagri and Risgan), Bilaspur division (Lormi and Baikuntpur), Baster division (Tiria forests), and Mandla division (Bikrampur and Aamer). The forests have been studied by belt transact (20′ wide and at least 10 belts in each forests run across the contours. The size of the quadrat (20′ × 20′) has been arrived at by species area curve.

Analytic characters including qualitative and quantitative and the synthetic ones of the forests have been described. The paper further gives density diagrams of the different forests and polygraphs showing abundance, frequency and cover of Sal in these regions.

In total about 30 trees species have been recorded to grow with Sal in the different forests examined. None of them is a constant associate of Sal. The following species occur in at least 4 out of 6 divisions studied : *Terminalia tomentosa, Madhuca latifolia, Pterocarpus marsupium, Buchnania latifolia and Anogeissus latifolia.* Layering is present in the forests. Sociability of Sal is great. Heavy regeneration adds to the sociability value. S. Raipur division (Nagri and Risgan) has the best Sal growth having 90 ft. or more tall trees and good cover. On an average 2·5 number of adult plants with 74·75% of cover and 2 to 3 sapplings of Sal occur in each quadrat in this division. Baster (Tiria forests) and Balaghat division (Mukie) fall next in line. The trees are 70 ft. to 90 ft. tall with 83% to 86 of cover, respectively. Number of trees, however, is greater in Mukie quadrats. Pachmarhi (Hoshangabad division) and Mandla division have poor growth with 66·66 and 43·3 of cover, respectively.

STUDIES ON THE UNDERGROUND PARTS OF *ALHAGI CAMELORUM* FISCH

By R. S. AMBASHT

Department of Botany, Banaras Hindu University

The underground parts of *Alhagi camelorum* has been studied. Their behaviour for continued growth and propagation of the species during drought, erosion and silting of the substratum has been worked out. Perennation of the plant under inundation is also described. The underground stem has been found to be covered with dormant buds upto a great depth which start rapidly growing on exposure provided a piece of root remains attached to it.

ROOT HABIT IN RESPONSE TO EROSION, SILTING AND INUNDATION

By R. S. AMBASHT

Department of Botany, Banaras Hindu University

The effect of erosion, silting and inundation on the root habit of a few herbs, trees and shrubs have been examined in field and in culture experiments. Each species seems to respond in its own way to the intensity of physiographic factors. Erosion and waterlogging promote root branching in *Euphorbia hirta.* Similar effect of waterlogging is also seen in *Ruellia tuberosa* and *Phyllanthes niruri.* Formations of new zone of rootlets on main stem of *Ricinus communis* seedlings due to silting has also been noticed. Roots developed under waterlogged conditions or submergence are white in colour.

EFFECT OF VITAMINS AND HORMONES ON THE GROWTH OF *P. MALORUM* AND *P. PSIDII*

By M. P. TANDON

Department of Botany, University of Allahabad

The action of the growth promoting substances was not uniform. Nicotinic and ascorbic acids inhibited the growth. Addition of thiamin increased yield of the two fungi. Best results were obtained when thiamin was added at a concentration of 20 or 30 I. U. per 100 c. c. of the solution.

Growth of *P. malorum* improved with an increase in the concentration of lentil extract or indloe-propionic acid. *P. psidii* responded similarly when lentil extract was added to its nutrient medium, but indole-propionic acid was best utilized by it only when added at a cocentration of 0.0001%. Lower concentrations also supported good growth but at higher concentrations the growth was unsatisfactory. Addition of indole-3-acetic acid in low concentrations to the nutrient media improved growth of both the fungi, but its higher concentrations were found unfavourable. Chlorophenoxy-acetic acid was best utilized by both *P. malorum* and *P. psidii* when used at a concentration of 0.0001%. Its use in higher or lower doses was not so favourable.

A study of the macroscopic and microscopic characters revealed that on the addition of growth promoting substances the character of mycelium and spore was not modified.

AGRONOMIC PRACTICES IN SOIL AND WATER CONSERVATION

By G. S. PRASAD

Soil Conservation Research, Demonstration and Training Centre, Dehra Dun

Vegetation is the nature's defence in combating the soil erosion menace as well as the water loss. There are vast areas when deprived of vegetation alone have undergone severe erosion-cutting these bare land into gullies and ravines. Such a state of affairs is always detrimental to any nation and particularly as to India, which is basically an agricultural country with a vast population both human and bovine.

Land has to be cleared for growing food crops, but at the same time utmost attention is to be paid for protecting these lands to give sustained increased production. This can be achieved by adopting suitable agronomic practices which will initiate nature covering the land as long and as closely as possible.

CIRCULATION OF BLOOD IN THE RESPIRATORY REGION OF SOME FRESHWATER CATFISHES OF INDIA

By DEVENDRA B. SAXENA

Department of Zoology, D. A. V. College, Kanpur

All life originated in water and adaptation to life in air is secondary development. Although the adaptation took place in several animal phyla in extremely remote times we find even now a number of forms showing how it could come about. Such forms exist in many variations mainly in tropical freshwater fishes. In some there are special gills not collapsing in air and functional so long as they are kept moist. In others, special cavities, coated with respiratory capillaries, are kept filled with air. Some have developed accessory respiratory organs to increase the efficiency or to supplement the action of the gill. Many of these adaptations permit air-breathing, during deficiency of oxygen in water, allowing some obviously aquatic teleost to become temporary land-dwellers. Aerial respiration provides an example of a fundamental change in the functioning of one of the main systems of the body with resultant modifications of the correlated structures. The part of the circulatory systems, which is intimately connected with the respiratory organs shows, therefore, marked modifications along with the elaborations of respiratory mechanism.

The modifications in the chief blood vessels of the respiratory organs have however, not been satisfactorily worked out in freshwater fishes of India, with a view to compare aquatic and aquatic-aerial species. Carter and Beadle (1931) while discussing the blood-supply of the respiratorily organs in fishes went to the extent of saying "that the arterial supply of the respiratory organs as a rule is not of great interest." Moreover, they maintained, "If the accessory organ is on the direct course of branchial circulation (as in *Hypopomas*, *Clarias* and *saccobranchus* etc.) it is to be expected that no modification of either the main venous or arterial circulation would occur.) Das (1940) said that arterial supply of blood in airbreathing fishes is not of special interest. In reviewing the data complied by Carter and Beadle (1931) it is at once obvious that the accessory respiratory organs of the airbreathing fishes are supplied by blood of multifarious origin. It would seem that there are two possible factors governing the resultant blood supply namely, the initial organ from which the accessory organ is derived, and the morphological situation of the accessory organ. It matters little, what kind of blood the vessels may contain.

No published work is available on the circulatory system of *Rita rita*. In *Rita* the second pair of afferent arteries originate from one common aperture; so also the third and fourth afferent arteries of both sides originate from another common aperture. In *Heteropneustes* Burne (1896) did not go into the details of circulation of blood in the respiratory region, but only traced the fourth afferent arteries to the air-sac, to check up the work of Hyrtl (1853). According to Hyrtl the fourth afferent artery of the left and the first afferent artery on the right surpasses all the other afferent arteries in length to supply the air-sac. Burne's observations do not answer to this description, for he states that the afferent arteries are symmetrical. I have observed that only the two fourth afferent arteries are longer than the others and supply the air sacs.

In *Clarias lazera* Nawar (1955) has not observed the hyoidean afferen and while describing the origin of the afferent arteries he mentions. 'The second pair of afferent branchial arteries takes its origin directly from the antero-dorsal wall of the bulbus, while the third and fourth pairs branch from the common short trunk which originates from the mid-dorsal surface of the bulbus; internally its origin is marked by a wide oval opening.' As observed by me in *C. batrachus*, the opening for the common origin of the third and fourth pairs of afferent arteries is situated in the dorsal wall of the ventral aorta near its origin from the bulbus; while the second pair of afferent arteries originates a little anterior to the common aperture of the third and fourth afferent arteries by its independent lateral openings. These openings are so closely situated to the anterior end of the bulbus that they appear to originate from the bulbus it self.

In *Labeo rohita*, a typical non air-breathing freshwater fish four pairs of independent afferent arteries, each with a separate opening (Das and Saxena '56). In *Rita, rita, Clarias batrachus* and *Ophicephalus striatus* the third and fourth pairs of afferent arteries originate from a single aperture in the roof of the ventral aorta; whereas in *Mastacembelus armatus* (Saxena '56) the openings for the origin of the third and fourth pairs of afferent arteries are closely situated. From this condition the common origin of the third and fourth pairs of afferent arteries seen in *Rita, Clarias* and *Ophicephalus* may easily be derived. In *Heteropneustes fossilis* the second, third and fourth pairs of afferent arteries all originate from the same aperture in the dorsal wall of the ventral aorta. In my opinion this is clearly an advance over all freshwater fishes in India worked out so far. It would not be an exaggeration to state that a further advance in this line (of the origin of afferent arteries by common root) would lead us to the anphibian condition,

where all four pairs of afferent arteries have a common root, as in a 12 mm. tadpole of *Rana tigrina*.

The elaboration of the afferent branchial arteries especially those vessels arising from the circulus cephalicus, have not been traced in the past in any detail, except by Ridewood in 1899. In *Rita* and *Clarias* I observed that the first and second pairs of afferent arteries open into the circulus and the third and the fourth pairs of efferent arteries open into the aorta independently, immediately behind the circulus. In *H. fossilis* the first and second pairs of afferent arteries open into the circulus and the third and fourth afferent arteries of each side join together before opening into the aorta immediately after the circulus, The coronary artery in *Clarias* bringing blood from the accessory respiratory (arborescent) organ to the heart muscles has also not been described, to my knowledge, in any other Indian fish.

No satisfactory account of the venous circulation in the respiratory region is obtainable from published literature on the subject. The formation of large sub-pharyngeal sinus collecting blood from the floor of the pharynx and the buccal cavity in *Heteropneustes* is similar to the condition already reported in *O. striatus* (Das and Saxena '54).

In *Heteropneustes* the air-sacs are supplied by the fourth afferent artery and the blood is collected by corresponding afferent arteries. In *Clarias* the arborescent organs are supplied by the second and fourth afferent arteries and the aerated blood is collected by the corresponding afferent arteries.

CONTRIBUTIONS TO OUR KNOWLEDGE OF DIGENETIC TREMATODES III

By S. C. BAUGH

Zoology Department, Lucknow University

In this work, the author has described several new species of trematodes belonging to the families *Notocotylidae, Cyathocotylidae* and *Opisthorchidae*. Besides these new species, a new genous of trematode of the family *Opisthorchidae* has been described and *Notocotylus parviovatus* Yamaguti, 1934, has been recorded for the first time in India. The genera *Mesostephanus* and *Gogatea* have been critically reviewed. The new forms are characterized as follows : —

Paramonostomum fulicai sp. nov.

This species is characterized by the position of its genetal pore, tuberculated cirrus, extent of vitellaria, number of uterine coils, and relative size of cirrus-sac and metraterm.

Paramonostomum nettioni sp. nov.

This is distinguished by the position of its genital pore near the oral sucker, aspinose cirrus, extent of vitellaria, and number of uterine coils.

Mesostephanus neophroni sp. nov.

This species is characterized by the large size of its tribocytic organ, relative size of its suckers and pharynx, short oesophagus, and extent of cirrus-sac.

Cyathocotyle phalacrocoraxi sp. nov.

This is characterized by its extremely large tribocytic organ, relative size of its suckers, extent of cirrus-sac, and size of eggs.

Gogatea incognitum sp. nov.

This species is distinguished by the small size of its body, presence of a prepharynx, relative size of its suckers and pharynx, extent of vitellaaia and cirrus-sac.

Nigerina hardoiensis gen. nov., sp. nov.

This new genus of avain trematode is characterized by the shape and ruffled margins of its body.

Metorchis nettioni sp. nov.

This species is characterized by the size of its body and of other structures. and relative size of its suckers.

CONTRIBUTIONS OF OUR KNOWLEDGE OF DIGENETIC TREMATODES IV

By S. C. BAUGH

Zoology Department, Lucknow University

In this paper, the author has described some new trematodes of the families *Brachylaemidae, Heterophyidae, Schistosomatidae* and *Echinostomatidae.* The characteristic features of the different forms are as follows :—

Brachylaemus ratti sp. nov.

It is characterized by its prepharynx, relative size of its suckers and of gonads, extent of its vitellaria, and uterine coils.

Brachylaemus paradoxuri sp. nov.

This species characterized by its prepharynx and a short oesophagus, relative size of its suckers, and strongly muscular metraterm.

Leucochloridium nainitalensis sp. nov.

This species is characterized by the relative size of its suckers, distribution of its uterine coils, extent of its vitellaria, and relative size of its gonads.

Haplorchis vagabundi sp. nov.

This is distinguished by the size of its body and other organs, and position of ovary.

Trichobilharzia indica sp. nov.

This species is characterized by its males being larger than females, notched ventral sucker, oesophageal bulb, position of genital pore and character of eggs.

Ornithobilharzia phalacrocoraxi sp. nov.

This is distinguished by its aspinose body, labate ventral sucker, relative size of suckers, and number of testes.

SEXUAL DIMORPHISM IN *GARRA LAMTA*

By D. D. SONI

Department of Zoology, University of Saugar

Garra lamta shows well marked sexual dimorphism. This is specially noticeable in the character of the snout. In the male, there is a well developed deeped transverse groove immediately anterior to the nostrils while in the female this groove is represented by a hardly recognisable shallow groove. Moreover, in the male, both the dorsal as well as the lateral sides of the head are provided with numerous fine pores; in the female, however, these pores are considerably fewer in number.

THE EFFECT OF DIFFERENT CARBON COMPOUNDS ON THE GROWTH AND SPORULATION OF *HELMINTHOSPORIUM ROSTRATUM* DRECHSLER

By C. G. SHINKHEDE

Department of Botany, Mahakoshal Mahavidyalaya, Jabalpur

The influence of different carbon compounds on the growth and sporulation of *Helminthosporium rostraum* Drechsler was studied. The best growth of the fungus was obtained on maltose and glucose. Mannose, galactose, sucrose and arabinose supported good growth. It was fair on starch and poor on mannitol and sorbitol. Growth was absent in the medium devoid of any carbon compound.

Sporulation was very good on maltose and arabinose. It was good on mannose, glucose, mannitol and sorbitol, starch and sucrose induced only fair sporulation.

HAPLOIDY IN THE TEMPERATURE TREATED EGGS OF *GASTEROSTEUS ACULEATUS*

By H. SWARUP

Department of Zoology, University of Saugar

During the experiments on the production of polyploidy in *Gasterosteus aculeatus* by temperature shock at the Zoological Laboratories Oxford, it was observed that a number of haploids were also produced. These haploids did not develop beyond the hatching stage and were apparently very weak. The possible mechanism for the production of these haploids seems to be androgenesis.

THANATOSIS RESPONSE OF BEETLES TO PYRETHRUM AND NICOTINE POISONING

By S. C. SAXENA

Department of Zoology, University of Saugar

It is believed that pyrethrum affects the sensory nervous system of the beetles (*C. granaria, C. oryzae, C. septempunctata, A. bipunctata*) and produces trains of impulses, thus promoting the thanatosis response at certain concentrations. It

appears that higher concentrations produce a state similar to 'fatigue' when the insects fail to show thanatosis response. Nicotine does not seem to affect the sensory nervous system in this way.

STUDIES ON THE WING VENATION OF GENUS *AULACOPHORA*

By R. S. SAINI

Department of Zoology, University of Saugar

The wing venation belongs to a highly modified cantharid or telephorid type. The characteristic median loop formed at some distance from the apex of the wing, by the fusionof the two median veins, is absent; the loop at the apex of the radial veins is present and is formed between radius and radial sector veins and by rr; transverse veins joining cubitus and anal veins are absent; the proximal portion of the first anal vein is also absent.

STUDIES ON THE SCALES OF FERESHWATER FISHES OF INDIA AND THEIR IMPORTANCE IN AGE DETERMINATION AND SYSTEMATICS: PART I. THE TYPES OF SCALES

By S. M. DAS

Department of Zoology, University of Lucknow

The use of scales in age and growth studies have been confined in the past to marine fishes in the main. No detailed studies of scales of freshwater fishes have ever been undertaken in India and few data exist even for the economically important species. The main types of scales in Indian freshwater fishes are : (1) *Gonoid* rhombic scales of the gar-fishes e.g. *Xenentodon* : (2) *Cycloid* imbricate scales of carps and glassfishes e.g. *Labeo, Barbus* and *Ambassis* ; and (3) *Ctenoid* overlapping scales of perches e.g. Anabas and Nandus. The scales are large and overlapping in *Barbus tor;* well-marked and overlapping in *Labeo* species small and overlapping in herrings and featherbacks (*Hilsa ilisha* and *Gadusia chapra, Notopterus notopterus* and *N. chitala*) ; small and tile-like in *Oreinus* and Schizothorax; snake-like head shields in the murrels (*Ophicephalus*), rudimentary and embedded scales in the loaches (Botia. *Lepidocephalichthys* and *Nemachilus*) ; and finally the scales are absent in the catfishes (*Clarias Heteropneustes, Wallagonia, Chaca, Silonia, Mystus, Rita* and *Bagarius*).

The scale of the Mahaseer *Barbus tor* exhibits the *focus, radii,* and concentric *circuli* very well. The circuli are not the rims super-imposed laminae (the common view) but of transparent homogeneus hyalodentie. A few annuli are marked by a clear narrow streak encircling the focus and this *clear zone* may aid in determining the approximate location of the *annual ring* on the scale. But "spawning checks" in annuli growth and "false annuli" due to resorption, interruption in growth due to injury, disease or spawning have to be carefully ruled out. Generally speaking the Indian Gar-fishes do not show any annual rings of growth on the scales ; a few Indian Herrings (*H. ilisha*) often show the annual rings ; the Indian carps ordinarily have no rings of growth, although the Rainbow trout shows them distinctly ; the Indian Perches show the rings after the second year; and the Globe fishes show the rings best. These main types of scales are detailed for the first time in the present conribution.

THE FUNCTIONAL ANATOMY OF THE URINO-GENITAL SYSTEM IN THE LIZARD *UROMASTIX HARDWICKII* GRAY

By S. M. DAS

Department of Zoology, University of Lucknow

The structure and function of the Urino-genital system has not been worked out in any Indian lizard except for *Hemidactylus* (Mahendra 1953, Khalil 1951 and Seshadri 1956) and for some notes on the genitalia. *Uromastix* is not only a type in the Zoology courses in India, Pakistan, Burma and Ceylon but is more primitive and larger than *Hemidactylus*.

The kidneys are elongated pear-shaped structures lying free in the anterior half of their length but fused in the posterior half, although internally the fused parts are not actually united. The ureter openings are separate and lie posterior to the vas deferens openings, and are not united as in *Hemidactylus*. The bladder has a rounded funds and a narrow neck towards the Urodacum. The urine in the bladder is semi-solid, but the excreted urine is a whitish crystalline mass ejected as a posterior appendix to the faecal pellets. The urine filtered by glomeruli is liquid, but water is largely resorbed in the convoluted tubules and finally in the cloacal chamber.

The testes are ovoid and placed asymmetrically for anterior to the kidneys. A Mullerian vestige is always present at the antero-median border of the testes. The epididymis is wellmarked and the vasa deferentia open separately into anterior part of Urodaum. The hemipenis of *Uromastix* is a hallow sac with a distinct hardened pedicil, a soft anterior glans, and a sulcus along inner wall when everted. A groove connects the sulcus to the openings of the vasa deferentia. This is the first report on the hemipenis of *Uromastix* unfortunately omitted by McCann (1946).

The irregular ovaries are located nearer the kidneys than the testes and contain eggs in various stages of development. The oviducts present a striated appearance and each is enlarged into a shell-gland or ovisac at the posterior and, the last part functioning as a vagina for discharge of sperms at copulation.

THE FUNCTIONAL ANATOMY OF THE URINO-GENITAL SYSTEM IN THE SNAKES *ERYX CONICUS* BOULENGER AND *PTYAS MUCOSUS* LINNE

By S. M. DAS

Department of Zoology, University of Lucknow

In *Eryx conicus* the kidneys are depressed, spindle shaped, very asymmetrical, and much lobulated or segmented, the right being far ahead of the left. The segments in each kidney always number five, the first and the fifth being cones directed inversely. The ureter originates at posterior margin of the first lobe and runs on its ventro-median line—a condition reported for the first time in Indian reptiles. The free ureters are somewhat longer in the female, and they do not join the vasa deferentia in the male, opening separately into the hind part of the Urodaeum. There is no urinary bladder and the excreted urine lies in the cloacal chamber, being expelled as a solid mass along with the foceal pellets in *Eryx*.

In *Ptyas mucosus* not only are the kidneys asymmetrical but the right kidney is much longer than the left in the male snake, the number of segments being 20 for

the right and 12 for the left. In the female the right kidney has 12 segments and the left only 9, although the lobes are broader and stouter than in the male. In the male each ureter crosses under the vas deferens of its side, while in the female each makes a wide loop under the enlarged oviduct. There is no urinary bladder and the urine is a crystalline whitish solid.

In *Eryx conicus* the testes are bean-shaped and often mistaken for kidneys. Each testis is smooth and without any lobes or segments a feature in which *Eryx* resembles the Lacertilia than the Ophidia showing its primitive condition. The epididymis is narrow and the vas deferens long and opening into a dorsal pouch of the urodacum. Each hemipenis is shorter and stouter than that of *Ptyas*. In *Ptyas* the testis are acutely asymmetrical and placed almost in a line, each consisting of 5 to 6 lobes. The epididymis is much convoluted and the vas deferens very long. Each hemipenis has the sulcus on its inner margin.

The ovaries are very long in *Eryx*, the right being longer than the left. Each ovary has a double lamella of eggs and the oviduct runs straight back to open in a special chamber in the urodaeum. There is no distinct ovisac. In *Ptyas* also the right ovary is much larger than the left, each ovary however, consisting of only one lamella of a single row of eggs. The long wavy oviduct is enlarged posteriorly into a thickwalled ovisac, the posterior part of which is used in copulatian.

ON THE ANTERIOR VEINS OF *UROMASTIX HARDWICKII* GRAY

By S. M. DAS

Department of Zoology, University of Luchnow

No description of the anterior veins of *Uromastix* is available, although it is taught in almost all the Universities of India, Pakistan, Burma, and Ceylon. Bhaita (1929) wrote a paper entitled "The venous system of the lizard *Uromastix hardwɔcku*", but has surprisingly entirely omitted the anterior veins both in his diagrams and descriptions. This is therefore the first account of the anterior veins.

The two anterior vena cavae falling into the narrow sinus venosus, are short and stout receiving the intercostals, the subclavians and the jugular veins at their anterior ends. At its posterior end, before joining the sinus venosus, each anterior vena cava receives a long pharyngo-tracheal vein, the two pharyngo-tracheals being joined by four characteristic tracheal loops. Each jugular is enlarged to form a jugular sinus that receives a stout auricular vein from the region of the ear and the skin. The long jugular vein is formed anteriorly by the junction of the internal and external jugulars. The internal is stouter and receives the cerebral and orbital veins, while the external jugular receives the mandibular and the facial veins. This arrangement is unlike that found in *Hemidactylus* (Mahendra 1942) or *Varanus* (Thapar 1921).

FUSARIUM ROT OF CITRUS FRUITS

By R. N. TANDON *and* R. S. RAWAT

Department of Botany, University of Allahabad

A Fusarium Sp. causing fruit rot of Citrus was isolated from Allahabad. It caused a storage rot of Citrus fruits. The usual mode of infection was through the stem end or a injury. The effect of humidity, temperature, and age of fruit

on the spread of disease was studied. A number of Citrus were inoculated and it was found that *C. reticulata* and *C. limonia* were most susceptable while *C. grandis* was immune. Laboratory evaluation of fungicides revealed that Dowicide—A, U. N. R., Ceresan and Cuprovit were the most effective fungicides. Under storage condition the fruit rot was prevented by using Dowicide—A. O. 2% spray or by dusting with Ceresan. 2-4-D sprayed at 500 p. p. m. strength could not control the disease.

The Fungus secreted the following extracellular enzymes; amylase, invertse, cellulase, pectinase, crypsin and urease.

THE INFLUENCE OF SULPHUR SOURCES ON THE GROWTH AND SPORULATION OF *PHYLLOSTICTA CYCADIA* (PASS), *P. ARTOCARPNIA* (SYD ET BUTL)

By R. N. TANDON *and* K. S. BILGRAMI

Botany Department, Allahabad University

The influence of ten different sources of sulphur was studied on the growth and sporulation of *Phyllosticta cycadia* and *P. artocarpina.*

Magnesium sulphate and cystein were best sources. Good mycelial growth was also attained on potassium sulphate, sodium thiosulphate, sodium bisulphate and potassium persulphate. Sodium bisulphate was a moderate source, while ammonium sulphate and thiourea were significantly poor sources for both the organisms. These fungi failed to grow on zinc sulphate or on media which were devoid of any sulphur.

Magnesium sulphate and potassium sulphate supported excellent and good sporulation respectively of both the species. Poor sporulation was recorded on potassium persulphate, sodium thiosulphate and thiourea. There was no sporulation on ammonium sulphate. Sodium bisulphate was good and fair for the sporulation of *P. artocarpina* and *P. cycadina* respectively, while sodium bisulphate was fair for both the species.

Different concentrations of magnesium sulphate (which was the best sulphur source for both the species) were used and it was found that best growth of *P. cycadina* and *P. artocarpina* was attained when the concentration of MSO_4 $7H_2O$ was 1·5 and 1·25 gms. per litre respectively.

THE UTILIZATION AND SYNTHESIS OF OLIGOSACCHARIDES BY TWO SPECIES OF *PESTALOTIA*

By R. N. TANDON *and* K. S. BILGRAMI

Botany Department, Allahabad University

The utilization of oligosaccharides by two species of *Pestalotia* viz. *P. citri* Mundkur and Keshwala (isolated from the diseased leaves of *Citrus grandis*) and *P. banksiana* CAVARA (isolated from the diseased leaves of *Grevelia robusta*) was studied. Chromatographic technique was used to detect the presence of various sugars formed during assimilation. Three sources of nitrogen viz. ammonium chloride, asparagin and potassium nitrate were separately supplied in combination with different oligosaccharides.

Raffinose, sucrose and maltose were used after hydrolysis. Only two sugars viz. melibiose and levulose were obtained during the assimilation of raffinose. The levulose fraction was utilized faster while the melibiose fraction persisted upto the 15th day.

Sucrose was a good source. Chromatographic results showed that its both the components viz. glucose and fructose were utilized by these fungi. *Pestalotia citri* assimilated glucose earlier than fructose. *P. banksiana* also behaved in the same manner when asparagin or NH_4Cl were used as nitrogen sources, but with potassium nitrate the assimilation of both glucose and fructose was almost simultaneous. *P. banksiana* synthesized an oligosaccharide (Rf 0. 51) on sucrose-asparagin medium.

Maltose was the best sugar for both the organisms. These fungi converted maltose by transglucosidation into an oligosaccharide (Malto triose) with simultaneous liberation of glucose.

Cellobiose, lactose and melibiose were poorly utilized through a nonhydrolytic pathway. Melibiose (which is a component sugar of raffinose) influences the assimilatlon of raffinose.

Both the organisms prefered the ammonium nitrogen (NH_4Cl) which was followed by asparagin and KNO_3 respectively. It was observed that with certain exceptions the oligosaccharides or their hodrolytic products were assimilated slightly earlier if ammonium chloride was used as a source nitrogen.

A combination of maltose NH_4Cl was best for both the organisms. Cellobiose and melibiose were worst carbon sources for *P. banksiana* and *P. citri* respectively.

EFFECT OF N-P-K COMBINATION TREATMENTS ON HORDEUM VULGARE (L) AS REVEALED BY LEAF ANALYSIS

By NIRANJAN DAS

Department of Botany, University of Allahabad

The effect of nitrogen, phosphate and potash in different combinations applied at one level of 40 lb. per acre of each of the constituents had been investigated on barely (var. C 251). The experiments were laid out statistically in the field. The combinations were NK, PK, NP and NPK apart from a control. A record of height, tiller number, leaf number, leaf area, leaf and stem dry weight were taken at the vegetative, heading and milky grain stages i. e. 50, 70 and 90 days after sowing. Along with growth record leaf analysis was also done at these very stages for N, P_2O_5 and K_2O. Final yield of straw and grain was also recorded. The results were statistically analysed.

The treatments were found to have influenced all the characters profoundly. Maxmum height was recorded in NPK treatment at all the stages, while control plants had the lowest vertical growth. Tiller and leaf number and leaf area was maximum in NP at all the stages followed by NPK. Leaf dry matter was maximum in NPK treatment at the vegetative stage but at later stages NP had higher leaf dry weight than NPK. Stem dry matter recorded maximum value under NP treatment at the vegetative and milky grain stages whereas at the heading stage NPK recorded slightly higher stem weight.

Both grain and straw yield showed maximum value under NP treatment and minimum in control and treatments when arranged in decreasing order were NP > NPK > PK > NK > C.

Leaf nitrogen was maximum in NPK treatment followed by NK, NP, PK at the vegitative and heading stages. At the milky grain stage NK had highest NP lowest nitrogen percentage. Leaf phosphoric acid was maximum in NPK, PK and NP at the vegetative, heading and milky grain stages respectively. Control had lowest P_2O_5 at all the stages. Leaf potash was maximum in PK at vegetative stage and in NP treatment at the heading stage. At the milky grain PK showed maximum values and NP minimum.

The uptake of nutrients as revealed by leaf analysis showed that in general there was increased uptake of that element which was applied to the soil. Further, from the above mentioned results it is evident that our soils are poor in both nitrogen and phosphorus and the absence of either of these leads to compratively poor growth and yield as against a combination of these two nutrients. Potash on the other hand did not show any marked beneficial response which is indicative of the the fact that the soils do not need potash application. The treatments having all the three nutrients did not in any way prove better than a combination of only N and P. Thus the fact is amply borne out by the present findings that our soils need an application of nitrogen and phosphorus only, for the best results.

SOME ASPECTS OF LIVER AUTOLYSIS IN CONGESTED HEART FAILURE CASES

By H. B. TEWARI

Department of Zoology, University of Lucknow

In congested heart failure cases it has been observed that there is an abnormal growth of Collagen fibres around the blood channels. In the initial stages the Collagen fibres make their apparances around the central veins and the portal canals. Later on the growth of the Collegan fibres is extended around the sinusoid spaces also. Gradually the coating of the Collagen fibres become thickened around these spaces resulting in wall like partitions between the sinusoid spaces and the hepatic cells. Naturally such a development interferes with the osmosis and permeability of the nutritive fluids between the sinuisoid spaces and the hepatic cells. Such a tendency also leads to the disturbance of fat metabolism in the liver or in other words results in the production of intense anoxia (fatty infiltration due to lack of oxygen). The correlation of development of Collegen fibres and intense anoxia is well afforded by sections fixed for the demonstration of fat (Ludford's modification of Mann-Kopsch). It is also interesting to note that in such a condition in hepatic cells the mitochondria are very few and scanty—a condition very much opposed to the normal one where we find mitochondria in abundance. This speakes of the decrease of the functional activity of the liver cells.

In the next stage of hapatic degeneration the Collagen fibres invade the entire area as strands scattered in irregular directions. Further spreading of these fibers result in network like appearance enclosing the pockets of degenerating hepatic cells in its meshes. The final stage in the death of the liver cells is reached with the complete disorganisation of the cell walls of the liver cells presenting the picture of clumped nuclei in the reticulum of the Colleagen fibers.

GIBBERELLIC ACID AND VERNALIZATION

By S. C. CHAKRAVARTI

Department of Botany, Government Hamidia College, Bhopal

Several workers have reported that treatment with gibberellic acid (G.A.) induces flowering in certain biennial plants in the same season and thus replaces the low temperature treatment normally required for the purpose. In these biennial plants extension growth and flowering go hand in hand and it is quite likely that GA replaces vernalization treatment incidentally by bringing about the former, which is an almost universal effect of the chemical. It was thought desirable to put this suggestion to test by determining the effect of GA on the flowering of both vernalized and normal plants of *Brassica campestris* L., T. 10 S. 13, *Cicer arietinum* L., T. 87 and *Linum usitatissimum* L., T. N. P. 9, none of which have an obligatory low temperature requirement. In *Brassica* flowering results in a change in the growth habit of the plant from that of rosette formation to stem elongation, while in *Cicer* and *Linum* it is not so.

Treatments consisted of:—(*i*) post-and pre-vernalization soaking of seeds; (*ii*) soaking of ordinary seeds and (*iii*) several sprayings to runoff and dropping on the leaf whorl or on the youngest leaf at the apex with 100, 25 and 1 ppm. of the chemical.

Leaves on the treated plants of *Cicer* and *Linum* developed slight chlorosis and there was an overcrowding of them in the apical region in the former, at an advanced age.

Spraying and dropping treatments with GA brought about considerable extension growth in both vernalized and normal plants of *Cicer*, while there was hardly any effect on *Linum* and the vernalized plants of *Brassica*. In normal plants of *Brassica* an early elongation of the shoot was recorded with 100 ppm. of G.A. In the absence of GA treatment, rudimentary flower buds could be detected in both normal and vernalized plants of this crop as soon as the shoot starts elongation. In GA treated plants, however, this was possible only when they attained some height.

There was a significant earliness of 5·0 days in the enthesis of the unvernalized plants of *Brassica* treated with 100 ppm. of GA in August sowing and 3·65 days, in October sowing over that of the normal ones.

As GA fails to bring about an effect similar to that of vernalization treatment in plants like *Cicer* and *Linum* with a continuous growth habit, it may be concluded that this chemical does not replace 'vernalin'.

FOLIAR ASH AND SAL DISTRIBUTION IN RELATION TO SOIL

By G. S. PURI

Botanical Survey of India, Poona

Earlier work conducted by the author had shown that *Shorea robusta* is a calcifuge. Foliar analysis of Sal for calcium content revealed that the first quality trees have lesser calcium content than the lower quality classes. Foliar ash and soil calcium show a close correspondence in the Sal forests of Madhya Pradesh. Further, the tree being evergreen does not indicate a marked seasonal variation in calcium content, as is obtained in the associate deciduous trees.

FOLIAR CALCIUM IN SAL (*SHOREA ROBUSTA* GAERTN)

By K. N. JAIN

Botany Department, Mahakoshal Mahavidyalaya, Jabalpur

The paper deals with the variations in the amounts of foliar calcium and ash with respect to soil pH and exchangeable calcium, along with the variations in uptake of mineral elements as affected by age in different Sal (*Shorea robusta* Gaertn) forests of Madhya Pradesh. The work has been further corroborated by the observations on the effect of Sal litters on garden and laterite soils.

The following observations have been made:—

1. Foliar ash of Sal increases with the qualities I to III and decreases with the lowest quality.
2. Foliar calcium follows the same pattern as that of foliar ash.
3. pH value of soil examined varies between 4·7 to 6·55 irrespective of Sal quality classes.
4. Soils from different geological formations have approximately uniform exchangeable calcium which ranges from 0·024% to 0·216%. However the amount of exchangeable calcium is inversely preportion to better Sal quality classes.
5. The presence of fairly good amount of exchangeable calcium and the growth of Sal in basalt, under certain set of climate, it appears that Sal is not a 'Calcifuge' species.
6. Percentage of foliar ash varies with the age, and shows its highest value in litters.
7. Sal leaves in the process of decomposition return their calcium to underliying soil.

CYTOLOGICAL STUDIES OF SOME MEMBERS OF THE MUCORALLS—THE CHONDRIOME

By B. B. S. RAIZADA

Department of Botany, Allahabad University

A study of the Chondriome of the following species of the order Mucorales was made:—*Absidia cylindrospora, Cunninghamellaechinulata, Rhizopus sontii, Choanephora cucurbitarum* and *Mucordispersus*. Mitochondria in the form of granules, rods and short filaments were seen. These structures could be stained with Janus green Hocht B and 2, 3, 5, triphenyltetrazolium chloride in living conditions. Sublime formal and Helley's liquid gave best results in the fixed condition. It was observed that high temperature upto 60°C had no effect on the structure of mitochondria. Formaline, absolute alcohol, ammonium hydroxide had no effect on them. Acetic acid and hydrochloric acid visiculized them while sulphuric acid and nitric acid altered the structure of the mitochondria.

SOME OBSERVATIONS ON THE EXCRETORY SYSTEM OF ADULT *FASCIOLA INDICA* VERMA, 1953

By KUNWAR SURESH SINGH

Department of Zoology, University of Lucknow

The excretory system of adult *Fasciola indica* Verma, 1953 has been studied in live and preserved specimens. The finer excretory ducts were seen arising not from the terminal ends of the larger ducts but from their bases. The flame cells which were reported to be absent in *F. hepatica* Stephenson, 1947) were observed in live specimens. The flame cells measure 0·025 × 0·018 mm. and are present all over the body.

STAGES OF TRANSITION IN AFFERENT BRANCHIAL ARTERIES FROM FISH TO AMPHIBIEN STAGE: A CASE OF CONVERGENT EVOLUTION

By DEVENDRA B. SAXENA

Department of Zoology, D. A. V. College, Kanpur

SYMPOSIUM

ON

PHOTO-CHEMICAL REACTIONS INCLUDING PHOTO-SYNTHESIS

ABSTRACTS OF PAPERS

PRESIDENTIAL ADDRESS

ON

"IMPORTANCE OF PHOTOCHEMICAL REACTIONS"

By PROF. N. R. DHAR

Director, Sheila Dhar Institute of Soil Science, University of Allahabad

In his Presidential address to the symposium on "Photo-chemical reactions including photo-synthesis in plants", Professor N. R. Dhar, observed that during the last 50 years a very large amount of experimentation has been carried on all over the World in determining the influence of infra-red, visible, ultra-violet, Rontgen rays, rays from radio-active substances on chemical and biological processes. These researches have thrown considerable light on the mechanism of chemical changes, free radicals and energy utilization as postulated in Einstein's law of photo-chemical equivalence, which has been applied to the formation of carbohydrates in plants.

Prof. Dhar pointed out that Photochemistry has immense practical utility. Food stuffs, the fuel which supply the energy of all animal life are built up by the action of sun light in plant leaves where the inert carbonic acid is converted into energy producing materials by the absorption of solar light. Coals, oils and natural gases, which form the life blood of our mechanised civilization, represent the stored vegetation of the past. The Photosynthesis of Vitamin D from ergosterol, the treatment of tuberculosis, pernicious anaemia, rickets and other diseases are every day use of light radiations. Ultra-violet rays are used in sterilizing water, milk, medicinal products, in the testing of the fastness of dyes, inks and pigments, manufacture of synthetic rubber, drying of oils and varnishes and even in the detection of crimes and impurity in food stoffs. Photography which utilizes light radiations has developed into a big World Industry.

The researches carried on by Prof. Dhar and co-workers, have definitely established that a mixture of straw, leaves, water hyacinth, saw dust, grass etc. with bone or phosphate rocks or basic slag of the Indian Steel Industry containing 8 to 10% phosphoric acid, when ploughed in the land fixes atmospheric nitrogen and makes the land fertile by supplying the most important plant food materials e.g.

nitrogenous compounds, phosphates, potash, and trace elements. In these fixation of nitrogen, sun light or artificial light is copiously utilized in making land more fertile and in producing more nitrogenous compounds in soils and crops. Hence light absorption can make land more fertile and this use of solar light all over the world is next in important to food production in the plant kingdom.

Jenks in 'Mother Earth, London', October 1957 has stated "this work in India is of great significance in relation to the problem of feeding the World's growing population".

Moreover Dr. Aslander of Stockholm, Sweden, has stated that "the discovery of this kind of nitrogen fixation will certainly be counted among the most important ones regarding soil fertility."

Dr. A. C. Hildreth, Superintendent, United States Department of Agriculture has noted "this work is a great contribution to Agricultural Science. Your experiments on photo-chemical fixation of nitrogen are most interesting. They do much to explain the continued productivity of land in parts of Asia that have been farmed for thousands of years. More important, they offer hope for the future".

INFLUENCE OF LIGHT ON THE NITRIFICATION AND NITROGEN LOSS, IN THE NITRIFICATION OF AMINO ACIDS

By N. R. DHAR[1] *and* S. R. HASAN

Sheila Dhar Institute of Soil Science, University of Allahabad

Experiments carried on with glycine, α-alanine, leucine and arginine, when mixed with either Ganges or Jamuna sand, made up to a moisture content of 20%, show that the amino acids undergo considerable nitrification, both in light and in dark. The amounts of nitrification and nitrogen loss are much greater in light than in the dark. The nitrification takes place in the following stages :—

$$\text{amino acids} \xrightarrow{+O_2} NH_3 \xrightarrow{+O_2} NO_2 \xrightarrow{+O_2} NO_3$$

In all all these processes, oxidation takes place and there is always the formation and decomposition of the unstable substance ammonium nitrite which breaks up according to the following equation.

$$NH_4NO_2 = N_2 + 2H_2O + 718 \text{ Cals.}$$

This decomposition of ammonium nitrite, which takes place slowly even in dark, has been observed by Dhar and coworkers to be accelerated by light absorption and acidity of the medium. This phenomenon plays a very important role in the loss of land fertility when virgin soils are broken for cultivation and in the loss of nitrogen gas when fields are manured by nitrogenous organic substances or fertilized by ammonium salts, urea, cyanamide etc. This loss of nitrogen in the gaseous state is a perfectly general phenomenon involved in the oxidation of ammonia, ammonium salts and other nitrogenous compounds and also takes place in bacterial nitrification. It has been observed that the addition of rock phosphate checks the loss of nitrogen.

PHOTOCHEMICAL NITROGEN FIXATION WITH WATER HYACINTH (EICHHORNIA CRASSIPES)

By N. R. DHAR *and* S. R. HASSAN

Sheila Dhar Institute of Soil Science, University of Allahabad

A large number of experiments carried on by us show that there is considerable atmostpheric nitrogen fixation, much more in light than in the dark, when finely divided water hyacinth is mixed with Ganges or Jamuna sand, made up to 30% mixture content of the system. The efficiency of nitrogen fixation, that is the amount of nitrogen fixed per gram of carbon oxidised is enhanced by adding different rock phosphates and basic slags. The nitrogen fixation has been found to be greater when the system is illuminated by a 500 watt lamp, than when exposed to a 100 lamp, showing that the light is absorbed and greater the intensity of light greater is the nitrogen fixation.

NITROGEN FIXATION WITH ENERGY MATERIALS RICH IN NITROGEN

By N. R. DHAR *and* MAYA SHANKAR LAL

Sheila Dhar Institute of Soil Science, University of Allahabad

In order to establish whether nitrogen fixation takes place when materials like sunn hemp (*Crotolaria Juniceae*), water hyacinth Eichhornia Crassipes, cow dung, which are fairly rich in nitrogen, allowed to undergo slow oxidation when mixed with soil in presence or absence of different phosphates, various experiments have been carried out. It has been established that an appreciable oxidation of carbon and an increase in the total nitrogen of the system take place. It has also been observed that when the system is illuminated and phosphates are added, the increase in total nitrogen is greatly enhanced.

INFLUENCE OF COWDUNG, DIFFERENT PHOSPHATES AND POTASSIUM CHLORIDE ON THE PHOTONITRIFICATION OF AMMONIUM SULPHATE

By N. R. DHAR *and* MAYA SHANKER LAL

Sheila Dhar Institute of Soil Science, University of Allahabad

Dhar and Gopalarao after making a detailed study of nitrification and nitrogen loss have announced that "nitrification in the soil is at least partly photochemical in nature taking place without the agency of bacteria under the action of sun light at the surface of various soils". We have now confirmed our previous observation that nitrification is partly photochemical in nature.

The influence of cowdung alone or when mixed with phosphates on the loss of nitrogen from ammonium sulphate when applied to soil has been investigated. The influence of different phosphates alone or when mixed with potassium chloride in nitrification has also been studied. The results clearly show that there is appreciable loss of nitrogen from ammonium sulphate at different intervals of time. It is, however, apparent that the loss of nitrogen is always more prominent in those systems which are exposed to light than those kept in the dark.

Another significant point that comes out of these investigations is that the presence of potassium chloride checks the loss to some extent. But the checking of loss by addition of materials like cowdung is greater than KCl.

The best results were obtained by the authors when corbonaceous materials plus potassium chloride along with vario is phosphates were added to the system.

AQUEOUS LINE OF MOLECULAR EVOLUTION

By KRISHNA BAHADUR *and* S. RANGANAYKI

Department of Chemistry, University of Allahabad

The study of the origin of life on the earth has now crystallized to the investigation of the molecular evolution of simple substances as amino acid, nucleic acid and adenylic acid like compunds into a complex structure as preliminary protoplasm which became the basis of the present day life. The role of different forms of energy in guiding and affecting this molecular evolution has been studied. It has been observed that, in an aqueous mixture of paraformaldehyde and potasium nitrate in the presence of a suitable catalyst, on irradiation with light, a number of amino acids are synthesised. These amino acids in aqueous solution are found to change constantly into one another and this photosynthesis led to the synthesis of most of the natural amino acids. It is further observed that in presence of colloidal molybdenum oxide as catalyst, the aqueous suspension of paraformaldehyde fixes atmospheric nitrogen on irradiation and a few amino acids are detected in the mixture. The experiments on the effect of irradiation of sterilised aqueous solutions of CO_2 in presence of colloidal molybdenum oxide show the formation of glycine and alanine.

The formation of peptides from amino acids in aqueous solutions was considered to be difficult because the formation of peptides requires energy. It has been observed that if a mixture of glycine, sucrose and water under sterilized conditions is exposed to sunlight in a quartzflask, a few peptides are synthesised. The solution of glycine acts as substrate for the synthesis of enzymoids in the presence of a suitable matrix and on irradiation with mitogenetic radiation. This not only involves the formation of peptides in aqueous solution but also proves the prominent role that irradiation plays in the duplication of molecules. The molecular matrix has the same mitogenetic absorption spectra as that of the enzymoid synthesised during the exposure.

It appears that in the amino acid solution irradiation helps in the formation of free radicals which undergo numerous permutations and combinations forming different molecular structures of short life period, with little or no change in energy level. In these systems if a molecule thus formed reacts with another molecule and the combination breaks up leaving one of the original molecules intact and the second molecule in fragments, this system will give certain absorption spectra. Under these conditions, the radiation used for irradiation will help more in the synthesis of such molecules which have the same absorption spectra.

Thus the irradiation of amino acid mixtures with mitogenetic radiations helped in the autosynthesis of various peptide linkages and compounds like enzymoids and proteins were synthesised and these in an era when the earth was perfectly sterilized due to the absence of living organisms, remained undercomposed for a long time and got chance of coupling, with adenylic acid and nucleic acid which were similarly synthesised and these combinations acted as self energy releasing duplicating systems

and these in turn acted as the preliminary protoplasm. The similarity in the protein molecular pattern indicates that much less molecular evolution has taken place. This is due to fact that molecular evolution is of recent origin i.e., it started only when the physico-chemical conditions of the earth were quite similar to that of the present day and this molecular evolution mostly followed the aqueous line of evolution as our experiments indicate and probably do not involve thermal synthesis which needs high temperature, uncommon on the surface of the earth after the physico-chemical conditions of the earth became as it is at present.

A SPECTROPHOMETRIC STUDY OF THE PERMANGANATE OXIDATION OF OXALIC AND CITRIC ACIDS

By N. R. SUBBARATNAM *and* A. K. BHATTACHARYA

Department of Chemistry, University of Saugar

PHOTOCHEMICAL REACTIONS IN VOLUMETRIC ANALYSIS

REDUCTION OF FERRIC IRON BY PHOTOCHEMICAL REACTION WITH OXALATE-MECHANISM

By G. GOPALA RAO, K. BHASKARA RAO *and* Mrs. G. SOMIDERVAMMA

Department of Chemistry, Andhra University, Waltair

APPENDIX I

SUMMARIES OF POPULAR LECTURES

PROGRESS OF SCIENCE

By Prof N. R. DHAR

Director, Sheila Dhar Institute of Soil Science, University of Allahabad.

In his popular lecture to the Annual Gathering of the National Academy of Sciences, India, at Jabalpur University, Professor N. R. Dhar stated that during the 15th and 16th centuries the experimental method and scientific spirit were well established in Europe by Paracelsus, Bacon, Boyle and many others, and there was steady progress of science and technology for nearly 500 years. The European was taught to depend on experiments in mastering the natural forces and he truthfully and rigidly carried on experiments and drew correct conclusions and was successful in mastering Nature. After the 8th century A. D., we, in this country, never took to experimentation and never accepted the experimental method and India lost her supremacy and independence. That is why we are backward and not so honest in our efforts and actions as an European who has developed more method and honesty in everyday life.

Many Indians may be expecting that a new era of plenty from the utilization of the atomic energy is likely to be ushered in for the benefit of the poor man. But, as atomic energy is still quite costly, this is not going to happen. Moreover, as the North-West European countries have followed the difficult path of experimentation for 500 years in obtaining knowledge, Russia for 350 years and India for only 50 years, the benefits from the atomic researches as well as from other scientific investigations should be directly proportional to the periods of time spent in the pursuit of scientific knowledge. In other words, India can have only 1/10th of the benefit obtainable in North-West Europe and 1/7th of that in the U. S. S. R. Moreover, a scientific or technical discovery made by a clever man working in isolation can only be utilized for the common man, when the community as a whole is advanced enough to take up the matter seriously.

The great leaders and other pioneers of the experimental method, notably Palissy, Black, Scheele, Priestley, Newton, Cavendish, Davy, Mendeleef, Berzelius, Bunsen, Darwin Mendel, Dumas, Boussingault, Faraday, Pasteur, Ross, Koch, made tremendous sacrifices in pursuing scientific endeavour and experiments and made the European nations more practically minded and truthful. They applied science to all problems of life and developed their natural resources, improved their agriculture and made Europe great and prosperous. It will be interesting to record here that Professor Emil Fischer when he was invited to join the Berlin University and Professor W. H. Perkin (Junior) to the Oxford University, these two eminent organic chemists made a condition that they would not attend committee meetings but will devote themselves entirely to research work and lectures.

Now it is well known that Emil Fischer who carried on his classical researches on sugars with the help of phenylhydrazine was slowly poisoned by this substance and thus he died prematurely in 1919. Similarly Madam M. Curie kept very indifferent health during the last part of her life, although the big doctors of Paris were anxious to help her. It was later on discovered that her sickness was mainly

due to slow poisoning by radium and other emanations which were always present when she was carrying on experiments. These two immortal scientists died prematurely in the service of science.

We have been very unlucky in this country because invaders came repeatedly to our land and enslaved us completely and instead of following the path of science, truth and progress, we became slaves physically, morally and mentally and I am sorry to say that this mental slavery is still persisting. Instead of working hard on scientific and correct lines, we have learnt to get on by attending useless meetings, by saluting, propaganda and saying 'yes' to the man in authority who may not be sound.

It seems that the progress of Indian Science during the last 50 years would have been much greater if as a nation we were more honest and the scientists under-went the same sacrifices as the Pioneers of science in North-West Europe during the 18th and 19th centuries. Moreover, some of our brilliant scientists, after giving up scientific pursuit, have become satellites to Ministers and have gone in administrative jobs.

A SCIENTIST ON THE "THRONE OF GODS"

By Dr. M. S. MANI

Deputy Director, Zoological Survey of India, Calcutta

Prof. M. S. Mani of the School of Entomology, St. John's College, Agra, organized and led three Expeditions to the North-West Himalaya for the study of the high altitude insect life of the nival regions. The Expeditions collected and made detailed observations on various aspects of the insect life above the timber-line and nearly up to an elevation of 6000 metres (20,000 ft) above mean sea level. The work of the Expeditions has proved to be of great fundamental importance in biology and has also opened up many new lines of research.

The lecture gives a non-technical account of the activities of the Expeditions and describes the enchanting beauty of the high Himalaya, the unclimed peaks and glaciers on which Prof. Mani and his team spent three summers and learnt many things. The lecture is illustrated by several kodachrome transparencies of the Himalayan scenes, the traditional abode of gods, photographed often from unsual angles.

THE ORIGIN OF THE SCENERY AROUND SAGAR

By Prof. W. D. WEST

Head of the Department of Geology, University of Saugar

At the start Prof. West pointed out that appreciation of the scenery of a country is enhanced if its origin is understood. The features of a scenery depend mainly on the nature of the rocks forming the land surface, modified to some extent by climate, by vegetation and by man. An understanding of the origin of a scenery is only possible, therefore, if the past geological history of the area has first been deciphered.

Around Sagar the rocks belong mainly to two groups: the brown Vindhyan sandstones, formed of sediments laid down in shallow waters perhaps 500 million years ago, and the black volcanic lavas known as the Deccan Trap, that were

erupted over the whole of western India about 50 million years ago In the northern part of the district there occurs a third type of rock, the granite of Bundelkhand, which provides its own distinctive scenery.

A study of the geology of the country around Sagar reveals that after the Vindhyan rocks had been deposited in shallow seas, the country was uplifted and became dry land, and has never again been below sea level. The work of rain and rivers then carved out a landscape in the uplifted Vindhyan rocks. Much later there occurred a great outpouring of volcanic lavas which filled up the valleys and covered the hills. At the conclusion of this volcanic outburst a new system of rivers developed on the top of the solidified lavas, and carved out new valleys. But as denudation proceeded the old Vindhyan hills that had been buried beneath the lavas became exposed to view once more; and as the lavas were softer than the Vindhyan sandstones they were more rapidly worn away, leaving the Vindhyan hills standing up as they had been before the volcanic eruptions took place. Thus the scenery that we see to the north of Sagar town, consisting of Vindhan hills standing up above valleys of Deccan Trap, is really an ancient scenery formed more than 50 million years ago, which has been preserved by the covering of lavas, and which has now been revealed to view once again by the removal of the lavas.

Prof. West also suggested that the formation of the lake at Sagar may have been due to the emergence of ridges of Vindhyan rocks that are now seen surrounding it on the north, after the softer Deccan Trap had been removed by denudation. These hard Vindhyan rocks acted as a barrier to the northward flowing streams, and so caused the formation of the lake.

APPENDIX II

LIST OF DELEGATES

1. Prof. P. S. Gill, Head of the Department Physics, Aligarh Muslim University.
2. Dr. G. S. Puri, Botanical Survey of India, Poona.
3. Dr. O. N. Perti, Head of the Department of Chemistry, D. S. B. Government Degree College, Naini Tal.
4. Shri D. Krishnamurthy, Lecturer in Chemistry, Government College, Kotah.
5. Dr. Devendra B. Saxena, Lecturer in Zoology, D. A. V. College, Kanpur.
6. Shri P. N. Mehrotra, Lecturer in Zoology, Ranchi College, Ranchi.
7. Shri V. K. Agarwal, Lecturer in Botany, H. D. Jain College, Arrah.
8. Dr. M. S. Mani, Deputy Director, Zoological Survey of India, Calcutta.
9. Dr. K. C. Bose, Head of the Department of Zoology, Bihar University, Ranchi.
10. Shri S. M. Kondapurkar, Department of Agriculture, Madhya Pradesh, Rewa.

UNIVERSITY OF ALLAHABAD

11. Prof. P. L. Srivastava, Head of the Department of Mathematics.
12. Dr. R. N. Tandon, Assistant Professor of Botany.
13. Dr. S. P. Mitra, Assistant Professor of Chemistry.
14. Dr. K. Majumder, Assistant Professor of Physics.
15. Dr. K. Bahadur, Assistant Professor of Chemistry.
16. Dr. D. Sharma, Assistant Professor of Physics.
17. Dr. H. L. Dube, Assistant Professor of Chemistry.
18. Dr. A. K. Dey, Assistant Professor of Chemistry.
19. Dr. S. P. Mushran, Assistant Professor Chemistry.
20. Dr. S. P. Tandon, Assistant Professor of Chemistry.
21. Dr. M. P. Tandon, Assistant Professor of Botany.
22. Dr. D. N. Verma, Assistant Professor of Zoology.
23. Dr. K. S. Bilgrami, Assistant Professor of Botany.
24. Shri G. D. Srivastava, Assistant Professor of Botany.

25. Shri K. K. Srivastava, Research Scholar in Chemistry.
26. Shri Dilawar Singh, Research Scholar in Chemistry.
27. Shri Rameshwar Prasad, Research Scholar in Chemistry.

SHEILA DHAR INSTITUTE OF SOIL SCIENCE, UNIVERSITY OF ALLAHABAD

28. Prof. N. R. Dhar, Director.
29. Shri P. S. B. Naidu, Research Scholar.
30. Shri S. R. Hasan, Research Scholar.

BANARAS HINDU UNIVERSITY

31. Prof. R. Misra, Head of the Department of Botany.
32. Shri R. S. Divedi, Lecturer in Botany.
33. Shri S. Narashima Rao, Research Scholar in Botany.
34. Shri P. S. Ramakrishna, Research Scholar in Botany.
35. Shri R. S. Ambasht, Research Scholar in Botany.
36. Shri V. N. Kaul, Research Scholar in Botany.
37. Shri S. S. Ramam, Research Scholar in Botany.
38. Kumari C. R. Rugmini, Research Scholar in Botany.
39. Shri S. Narashima Rao, Research Scholar in Mathematics.

UNIVERSITY OF JABALPUR

40. Dr. R. L. Nirula, Principal.
41. Dr. M. S. Rao, Professor of Geology.
42. Dr. Karam Singh, Professor of Zoology.
43. Dr. V. Gore, Professor of Chemistry.
44. Shri C. S. Raghavan, Reader in Mathematics.
45. Dr. S. N. Mehrotra, Reader in Geography.
46. Shri T. S. Murthy, Reader in Physics.
47. Dr. S. C. Pandeya, Lecturer in Botany.
48. Shri R. B, Malaviya, Lecturer in Zoology.
49. Shri C. B. L. Verma, Reader in Mathematics.
50. Shri S. Bose, Lecturer in Chemistry.
51. Shri A. S. Devagan, Lecturer in Chemistry.
52. Dr. G. P. Agarwal, Lecturer in Botany.

UNIVERSITY OF LUCKNOW

53. Dr. S. M. Das, Assistant Professor of Zoology.
54. Dr. H. B. Tewari, Assistant Professor of Zoology.

UNIVERSITY OF SAUGAR

55. Prof. W. D. West, Head of the Department of Geology.
56. Prof. A. K. Bhattacharya, Head of the Department of Chemistry.
57. Dr. S. N. Banerjee, Assistant Professor of Chemistry.
58. Dr. S. B. Saxena, Head of the Department of Botany.
59. Dr. L. P. Mall, Assistant Professor of Botany.
60. Dr. Y. D. Tyagi, Assistant Professor of Botany.
61. Shri H. R. Bhargava, Assistant Professor of Botany.
60. Shri T. S. Trivedi, Research Scholar in Botany.
63. Shri S. Bhattacharya, Research Scholar in Botany.
64. Dr. H. Swarup, Assistant Professor of Zoology.
65. Dr. R. Saini, Assistant Professor of Zoology.
66. Dr. G. S. Rao, Assistant Professor of Chemistry.
67. Dr. P. N. Awasthi, Assistant Professor of Chemistry.
68. Dr. Y. G. Kher, Assistant Professor of Chemistry.
69. Dr. S. P. Banerjee, Research Scholar in Chemistry.
70. Dr. K. G. Kaimal, Research Scholar in Chemistry.
71. Shri S. S. Sharma, Research Scholar in Chemistry.
72. Shri G. C. Jain, Research Scholar in Chemistry.
73. Shri P. C. Jain, Research Scholar in Chemistry.
74. Shri M. K. Dixit, Research Scholar in Chemistry.
75. Shri U. V. Seshaish, Research Scholar in Chemistry.
76. Dr. S. C. Saxena, Assistant Professor of Zoology.
77. Shri D. D. Soni, Research Scholar in Zoology.

APPENDIX III

COUNCIL OF THE NATIONAL ACADEMY OF SCIENCES, INDIA

1958

PRESIDENT

1. Prof. P. S. Gill, M. S., Ph.D., F.A.P.S., F.N.I., F.N.A.Sc., Aligarh.

VICE-PRESIDENTS

2. Prof. P. L. Srivastava, M.A. D. Phil., F.N.I., F.N.A.Sc., Allahabad.
3. Prof. A. C. Joshi, D.Sc., F.N.I., F.N.A.Sc. Solan.

HONORARY TREASURER

4. Prof. S. Ghosh, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Allahabad.

FOREIGN SECRETARY

5. Dr. R. K. Saksena, D.Sc., F.N.I., F.N.A.Sc., Allahabad.

GENERAL SECRETARIES

6. Dr. R. N. Tandon, M.Sc., Ph.D., D.I.C., F.N.A.Sc., Allahabad.
7. Shri S. Basu, M.Sc., F.N.I., F.N.A.Sc. New Delhi.

MEMBERS

8. Prof. N. R. Dhar, D.Sc. F.R.I.C., F.N.I., F.N.A.Sc. Allahabad.
9. Prof. Ram Ballabh, Lucknow.
10. Prof. S. Ranjan, M.Sc., D.Sc., F.N.I., F.N.A.Sc., Allahabad.
11. Prof. A. K. Bhattacharya, D.Sc., F.R.I.C., F.N.A.Sc., Saugar.
12. Prof. K. Banerji, D.Sc., F.N.I., F.N.A.Sc., Allahabad.
13. Prof. R. Misra, M.Sc., Ph D., F.N.I., F.N.A.Sc., Banaras.
14. Prof M. D. L. Srivastava, D.Sc., F.N.A.Sc., Allahabad.
15. Dr. B. N. Prasad, Ph.D., D.Sc., F.N.I., F.N.A.Sc., Allahabad.
16. Prof. Mata Prasad, D.Sc., F.N.I., F.N.A.Sc., Ujjain.

CONTENTS

The Mission Press, Allahabad